A decision-making tool for the selection of an appropriate integrated MSW management system for tropical Asian cities; the case of Bangkok

Werkzeuge zur Entscheidungsfindung für die Auswahl angepasster integrierter Abfallwirtschaftssysteme für tropische Städte Asiens, am Beispiel von Bangkok

Dissertation

zur Erlangung des akademischen Grades

Doktor-Ingenieur

an der Fakultät Bauingenieurwesen

der

Bauhaus-Universität Weimar

vorgelegt von

Johanne Hanko

Weimar, Deutschland 2007

Gutachter
Prof. Dr.-Ing. habil Werner Bidlingmaier, Weimar, Deutschland
Prof. Dr.-Ing. Klaus Fricke, Braunschweig, Deutschland
Prof. Dr. habil. Bernhard Raninger, Shenyang, China

Vorsitzender der Prüfungkommission
Prof. Dr.-Ing. Jölg Londong, Weimar, Deutschland

Tag der Disputation: 9 November 2007

ACKNOWLEDGEMENT

I would like to express my sincere appreciation to my mentor Prof. Dr.-Ing. habil. Werner Bidlingmaier for trusting in me, for supporting me in developing this decision-making tool, and for encouraging the research associated with this dissertation. He has always given me invaluable advice and shown me different perspectives thus opening a wide range of options and possibilities in waste management.

Also special thanks to my co-advisors Prof. Dr.-Ing. Klaus Fricke and Prof. Dr. habil. Bernard Raninger who kindly reviewed and gave valuable comments on my work.

To my husband Roberto, for his patience and understanding, and especially for encouraging me and even sometimes pushing me during certain difficult moments; this degree could not have been possible without his support.

To Antje Klaus Vorreiter, who introduced me to the expertise of Bauhaus-Universität Weimar, and who has always believed that I was capable of making a PhD considering the years of in the field experience I had in municipal and hazardous waste management; she has proven to be a real friend.

Finally, but not least, I must thank my mother and father, who unfortunately are no more of this world, but who have given me the strength and perseverance to attain this degree by teaching me the right values in life and also that anything is possible when there is will, sincerity, determination and hard work.

ZUSAMMENFASSUNG

Einführung

Tropische asiatische Entwicklungs- und Schwellenländer zeigten rasches städtisches Wachstum dadurch, dass Bauern einwanderten, um ein besseres Leben in der Stadt zu suchen. Dadurch ergab sich in vielen Städten ein Mangel an geeigneter Infrastruktur und an sozialen Diensten. Die städtische Müllversorgung bildet keine Ausnahme; sie wird sogar oft an das Ende der Prioritätenliste für städtische Aufgabenpläne gestellt, da dabei zuerst die Gesetze und Verordnungen formuliert und umgesetzt werden müssen. Das Problem des nicht entsorgten städtischen Mülls führt (mit Sicherheit) zu Luftverschmutzung, Krankheit und zur Verseuchung des Bodens und des Wassers. Diese Probleme stehen in tropischen Klimaten im Zusammenhang mit hoher Temperatur und Feuchtigkeit, mit heftigem Regen und mit häufigen Überschwemmungen. Stehendes Wasser und Ausschwemmung aus dem Abfall werden sehr schnell zu Brutstätten von Insekten, Nagern und Bakterien, und damit zu einer Gesundheitsgefahr für Arbeiter und die allgemeine Bevölkerung. Darüber hinaus kann Wasser- und Grundwasserverschmutzung/Kontamination zu einer ernsten Umweltzerstörung führen, mit direkten Auswirkungen auf die Wasserressourcen, und auf raschen Qualitätsverlust der pflanzlichen Erzeugnisse, des Rückgrates der meisten tropischen asiatischen Länder.

Müllentsorgung und die Verantwortlichkeiten

Lokale Regierungen müssen die öffentliche Gesundheit ihrer lokalen Bevölkerung sicherstellen und sind deshalb für die Müllentsorgung verantwortlich. Asiatische tropische Klimate sich rasch ändernde Müllzusammensetzung machen die Müllbehandlung und –entsorgung zu einer dauernden Herausforderung der Entscheidungsträger. Vor einer Entscheidung über das verwendete Entsorgungssystem muss eine geeignete Abfall-Charakterisierung treten. Diese Charakterisierung liefert Kenntnisse über die Abfallmenge, die Feuchte, den Heizwert und die Menge der verschiedenen Komponenten im Abfallstrom, wie z. B.: organisches Material, Plastik, Papier, Karton, Holz, Textilien, Gummi, Leder, Glas, Metalle, Nichtmetalle, Steine und Keramiken. Darüber hinaus ist die Herausforderung, der sich asiatische Länder gegenüber sehen, ein Mangel an Raum und damit wird die Platzierung eine Deponie zunehmend schwierig.

Die Abfallwirtschaft ist eine kostenintensive, aber trotzdem notwendige Maßnahme, um das Wohlergehen sowohl der Bevölkerung als auch für die Umwelt sicher zu stellen. Es wird geschätzt, dass Asien im Jahr 2025 etwa 47 Milliarden US$ aufwenden muss, um 0,5 bis 1 Kg städtischen Müll je Person und Tag abzufahren und zu behandeln, oder 5 US$ je Kopf und Jahr. In Entwicklungsländern sind unzählige Leute nicht in der Lage, diese hohen Preise für die Abfallentsorgung zu zahlen. Deshalb liegt es in der Verantwortung der Regierung, die Abfallentsorgung zu betreiben und zu finanzieren, um die Bevölkerung, die Gemeinde und die Umwelt zu schützen. Tropische asiatische Städte müssen jetzt bezahlbare und nachhaltige Verfahren für die Entsorgung ihrer zunehmenden Menge täglichen Abfalls benennen, wobei gleichzeitig auf minimale Umweltbelastung, auf soziale Akzeptanz und auf minimale Landverbrauch zu achten ist. Eine leicht anwendbare Entscheidungshilfe zur Wahl des geeignetesten Abfallbehandlungssystem der Gemeinde wäre deshalb sehr nützlich.

Proposition

Der Zweck dieser Dissertation war die Entwicklung eines nutzerfreundlichen Instrumentariums für das Verwaltungs- und Regierungspersonal in tropischen Entwicklungs- und Schwellenländer.

1. Diese Vorgehensweise basiert auf einem Netzwerk, das eine Liste ausgewählter entscheidungsrelevanter Tatsachen in Betracht zieht, die nötig sind, um eine informierte

Entscheidung machen zu können. Das entscheidungshelfende Verfahren muss von Entscheidungsträgern bei einer vorläufigen Feststellung des Abfallentsorgungs- und -behandlungssystems für ihre Gemeinde benutzt werden.

2. Tropische asiatische Städte müssen eine Reihe von Faktoren berücksichtigen, wenn sie über ihren Abfallwirtschaftsplan entscheiden. Dazu gehören die immerwechselnde Menge und Zusammensetzung des Abfalls infolge der zunehmenden Bevölkerungszahl und des Einkommens je Kopf, der hohe Feuchtigkeitsgrad, Verbrennungswärme-Werte und die oft begrenzten finanziellen Möglichkeiten.

3. Ferner sind gesetzliche, politische, verwaltungstechnische, soziale, finanzielle, ökonomische und technische Faktoren bestimmend.

4. Die Verwaltung muss dabei die Wichtigkeit jedes Teilschrittes der Abfallwirtschaft im Auge behalten, also Abfallerzeugung, Sammlung, Transport, Abfallcharakterisierung, Entsorgung und Behandlung.

5. Die Rolle der lokalen Gemeinden in der Entscheidungsfindung ist nicht hoch genug einzuschätzen; deshalb müssen Mitglieder der Gemeinde aktiv am Schutz der Umwelt und an der Verhinderung ihrer Zerstörung mitwirken. Mehrere Entscheidungshilfsverfahren für verschiedene Anwendungen wurden entwickelt. Jedoch zieht die Mehrzahl von ihnen nicht notwendigerweise eine öffentliche Teilnahme in Betracht, und sie sind auch nicht benutzerfreundlich.

6. Um die Komplexität der Probleme besser zu verstehen, die bei tropischen asiatischen Städten auftreten, wurde die Innenstadt von Bangkok, Thailands größte Stadt und Hauptstadt, als repräsentativer Fall ausgewählt, für die Entsorgung der 9000 t Müll der täglich produziert wird. Thailands Klima ist, besonders während der jährlichen Monsunzeit, heiß und feucht mit einer mittleren Temperatur von 28,4°C und einer Feuchtigkeit zwischen 70 und 100%. Die Gesetze und Verordnungen zeigen sehr deutlich an, wie wichtig die Behandlung des städtischen Abfalls genommen wird. Zahlreiche Interviews, verbunden mit der Durchsicht von Dokumenten, Berichten und Ortsbesichtigungen ergaben Kenntnisse der zahlreichen Entscheidungsmaßnahmen, denen sich die städtischen Entscheidungsträger einer tropischen Stadt gegenüber sehen. Die Durchsicht und die Analyse der Entscheidungsmaßnahmen in Bangkoks Abfallentsorgungsstrategien zeigten, wie das Entscheiden als Werkzeug in verschiedenen asiatischen tropischen Städten benutzt werden kann.

7. Ein Entscheidungsrahmen wurde erstellt auf der Grundlage von Literatur-Recherchen und persönliche Erfahrungen, und anhand der in der Stadt Bangkok gesammelte Daten überprüft. Die Entscheidungspunkte im Netzwerk umfassen eine allgemeine Beschreibung der Stadt, ihre klimatischen und hydrogeologischen Bedingungen, die Menge und Art des erzeugten Mülls, einen Überblick über die bestehenden Anlagen und die existierenden Programme, öffentliche Aufmerksamkeit zu gewinnen, den sozioökonomischen Aspekt eines Abfallbehandlungssystems und die öffentliche Teilnahme. Es berücksichtigt ferner Gesundheits- und Sicherheitsüberlegungen im Zusammenhang mit Abfallentsorgungsmöglichkeiten und ihrer Kosten.

8. Das Entscheidungsinstrumentarium hat als Ziel, ein geeignetes Abfallbehandlungssystem zu ermöglichen, das als Grundlage soziale, klimatische und technische Informationen benutzt. Ihre Einfachheit erlaubt einem Verwaltungspersonal, das wenig Erfahrung mit Abfallwirtschaft und Computerwissen besitzt, verschiedene Optionen zu analysieren und Szenarien auszutesten. Des weiteren werden verschiedene Möglichkeiten überprüft, und es wird versucht, die Optionen in die Abfallwirtschaft zu integrieren.

9. Das Instrumentarium beinhaltet über ein Hundert geschlossene Fragen, die auf das Analysieren der Bedürfnisse und der gegenwärtigen Situation der Abfallwirtschaft einer bestimmten Gesellschaft ausgerichtet sind und die es ermöglichen, ein geeignetes Abfallwirtschaftssystem für die entsprechende Gesellschaft zu wählen. Diese Fragen hatten als Grundlage die Rahmen und Eckpunkte des Entscheidungsinstrumentariums. Dieses Instrumentarium ist selbsterklärend, und gleichzeitig bietet es Flexibilität bei der Entscheidung, um wie viel Prozent des Abfalls wieder verwertet wird, kompostiert oder behandelt durch irgend eine von den sechs Behandlungsoptionen; Kompostierung, Vergärung, nicht-Verbrennungssysteme, Verbrennung, Deponierung und Energiegewinnung.

10. Die Ziele eines integrierten Abfallwirtschaftssystems können vom Benutzer geändert und modifiziert werden. Dies ermöglicht die Überprüfung verschiedener Szenarien und die Auswahl des geeignetesten Abfallbehandlungssystems. Das System kann sehr einfach sein und nur ein Behandlungssystem beinhalten oder mit einer Auswahl mehrere Behandlungssysteme sehr kompliziert sein. In einigen Ländern ist es Vorschrift mehrere Systeme anzuwenden. Integrierte Abfallwirtschaftssysteme, die mindestens zwei oder drei Abfallbehandlungssysteme beinhalten, sind deshalb gefragt.

11. Die Ziele der Gesellschaft sind ausschlaggebend und sind die Schlüsselfaktoren für den Entscheidungsprozess. Die Menge der wiederverwertbaren Materialien, die Brauchbarkeit des Komposts, die Interesse an Vergärung, die Möglichkeit einer Verbrennungsanlage, das Verstehen eines nicht-Verbrennungssystems und die Verfügbarkeit von Land für Deponien, die Notwendigkeit für Elektrizität sind einige Schlüsselfaktoren die überlegt werden müssen. Integrierte Abfallwirtschaft ist wahrscheinlich die vernünftigste Vorgehensweise. Dies ermöglicht Flexibilität bei Abfallwirtschaftstechniken und ergänzt sie gegenseitig.

12. Öffentliche Verwaltungen können DMT als eine erste Bewertung der geeignetesten Technologie benutzen. Des weiteren gibt DMT dem Verwaltungspersonal Flexibilität in ihrer Wahl bezüglich der Menge an wiederverwertbarem Abfall unter der Anwendung verschiedenen Technologien, welches eine gut konstruiertes und gut integriertes Abfallbehandlungssystem für die Gesellschaft darstellt.

Fazit

Das Fazit ist: die Abfallwirtschaft in einem tropischen Schwellenland ist mit bestimmten Herausforderungen verbunden, die behandelt werden müssen. Ökonomische, technische und soziale Kriterien müssen in Betracht gezogen werden bei der Wahl geeigneter städtischer Abfallwirtschaftsysteme. Begrenzte finanzielle Möglichkeiten, Mangel an öffentlichem Bewusstsein und ein schwaches Wirtschaftssystem sind manchmal verantwortlich für die Wahl eines schlechtes Abfallbehandlungssystems, mit kurzsichtigen und über die Jahren teuren Entscheidungen statt langfristigen und vernünftigeren Entscheidungen. Wetterbedingungen und die Knappheit an Land in Stadtnähe sind besondere Herausforderungen. Das Entscheidungsinstrumentarium DMT macht die Identifizierung von Schlüsselfragen nötig für die Formulierung eines nachhaltigen Abfallwirtschaftskonzepts und für die Wahl eines technisch-, ökonomisch- und sozial-akzeptierbaren Abfallwirtschaftssystems, das besonders geeignet ist für tropische Klimate.

Die Ergebnisse der DMT-Daten-Analyse bietet eine faire Auswertung für ein adäquates integriertes Abfallbehandlungssystems. Wenn einmal ein System identifiziert wurde, werden weitere Studien bezüglich Umsetzbarkeit und Anwendbarkeit nötig sein. Jedoch wird die Notwendigkeit, ausführliche Studien am multiplen Szenarien durchzuführen, minimiert, was erhebliche Ersparnisse für die Stadtverwaltung bedeutet. Eine Feasibility-Study und ein Masterplan haben zu folgen, um die standortspezifischen und Finanzierungsfragen zu klären sowie die Auswahl der spezifischen Anlagentechnik zu definieren.

Abstract

Developing and emerging tropical Asian countries have encountered fast urban development due to the migration of farmers seeking a better life in the city. This resulted in a lack of appropriate infrastructure and inappropriate social services in many cities. Municipal solid waste management is no exception and is in fact often placed at the bottom of the list of priorities for the cities' appropriate urban management plans since laws and regulations must first be formulated and implemented. The problem of unmanaged municipal solid waste certainly leads to air pollution, disease, and to soil and water contamination. These problems in tropical climates are compounded with high temperature, high-level humidity, heavy rainfall and frequent flooding. Stagnant water and leachate from waste quickly become the breeding grounds of insects, rodents and bacteria, thus creating a health hazard for workers and local populations. Moreover, water and groundwater contamination may lead to serious environmental degradation with direct impacts on water supplies, and in the fast degradation of agricultural products, the backbone of most tropical Asian countries.

Many cities still allow or tolerate dumping of waste in uncontrolled sites, and open burning that disperses particulates that most likely contain dioxins and furans. Even with increasingly scarce land availability within or in proximity of the cities, sanitary landfill is still the most often chosen disposal method around Asia because of its lower cost when compared to modern treatment systems. Yet, most of these landfill sites do not have proper lining, daily covering, methane recovery devices, leachate control systems, nor do they have long-term closure and monitoring plans, which implies short and long-term hazards. Some municipalities opted for incineration, which usually entails high operation and maintenance costs because of the need for supplemental fuel and often-inappropriate running conditions. Although tropical conditions appear to favor certain disposal systems such as composting, appropriate technology needs to be identified in order to reduce operation and maintenance costs while ensuring good quality outputs; compost plants have often been closed because of poor quality products due to the high content of plastic and glass particulates in the finished product. Tropical Asian cities are now required to identify affordable and sustainable solutions for the management of their increasing amount of waste generated daily, while ensuring minimal environmental impact, social acceptance and minimal land use.

The purpose of this dissertation was to develop a user-friendly decision-making tool for public administrators and government officials in tropical Asian developing and emerging cities. This tool was developed based on a list of selected decision-making issues necessary in making an informed decision. The decision-making tool is to be used by decision-makers in making a preliminary assessment of a most appropriate waste management and treatment system for their municipality. Tropical Asian cities must consider a number of issues when deciding on their waste management plan such as the continuously changing quantum and composition of waste associated with the increasing population and income per capita, the high humidity levels, and the often-limited financial resources. Other determinant factors include legal, political, institutional, social and technical issues. Furthermore, administrators must realize the importance of each stage involved in waste management, which includes waste generation, collection, transport, waste characteristics, disposal and treatment. To better understand the complexity of the issues involved in tropical Asian municipalities, the city of Bangkok, Thailand's largest city and capital, was selected as a case study for the management of

its 9,000 tonnes of waste generated daily. Numerous interviews, meetings along with the review of documents, reports and site visits offered an inside view of the tropical city's various decision-making issues towards its waste management plan, and examine specific problems encountered by the city's decision-makers. The review and analysis of the decision-making issues involved in Bangkok's waste management plan showed how the decision-making tool can be used in various Asian tropical cities.

In conclusion, waste management in an emerging tropical country involves specific challenges that need to be addressed. Economical, technical and social criteria need to be fully understood as to capacitate government officials in the selection of the most appropriate urban waste management system. Limited budgets, lack of public awareness and poor systems' management often cloud decision-makers in choosing what appears to be the best solution in the short term, but more costly over the years. Weather conditions and scarcity of land in proximity of the city make waste management especially challenging. The decision-making framework offers a tool to decision-makers, as to facilitate the understanding and identification of key issues necessary in the formulation of a sustainable urban waste management plan and in the selection of a technically, economically and socially acceptable integrated MSW management system. A detailed feasibility study and master plan will follow the preliminary study as to define the plant´s specifications, its location and its financing.

TABLE OF CONTENT

Acknowledgement iii
Zusammenfassung v
Table of content xi
Abbreviations, acronyms and units xvii
1. Introduction *1*
1.1. Waste management in Asian Tropical cities 1
1.2. Purpose of the dissertation 2
1.3. Research methodology 3
1.4. Organization of the dissertation 4
1.5. Section summary 5
2. Review of literature *7*
2.1 The Asian environment 7
2.2 The role of local communities in decision-making 8
2.3 Decision-making for sustainable MSW management 9
2.4 MSW management techniques and valorization 13
2.4.1 Choosing the right system 13
2.4.2 MSW collection 16
2.4.3 Valorization through recycling 17
2.4.4 Valorization through composting 18
2.4.5 Valorization through energy production 18
2.4.6 Landfilling, a necessity in developing countries 18
2.5 The decision-making process 19
2.6 Fuzzy logic for decision-making 20
2.7 Review of some existing waste management models and tools 22
2.8 Section summary 33
3. Identifying key issues *35*
3.1 Understanding local needs 35
3.1.1 Local development 35
3.1.2 Geographical aspects 38
3.1.2.1 Siting constraints 38
3.1.2.2 Topographical information 38
3.1.2.3 Climatic conditions 39
3.1.2.4 Existing environmental programmes 39
3.1.3 Human development 39
3.1.3.1 Demographic growth 39
3.1.3.2 Waste generation increase and changes 40

3.1.3.3 Population density 40
3.1.3.4 Infrastructure development 40
3.1.4 Waste characteristics 40
3.1.4.1 Volume and density 41
3.1.4.2 Moisture content and combustibility 41
3.1.4.3 Recyclability 41
3.1.4.4 Household hazardous waste 41
3.1.5 Social impact 42
3.1.5.1 Community participation 42
3.1.5.2 Cultural practices 42
3.1.5.3 Health 42
3.1.5.4 Employment generation 43
3.1.5.5 Considerations for the poor, women and children 43
3.1.5.6 Resource recovery and its social implications 43
3.1.6 Political implications 43
3.1.6.1 Workability of laws and regulations 44
3.1.6.2 Implementation and enforcement 44
3.1.6.3 Political will 45
3.1.6.4 Private sector participation 45
3.2 Technical issues 46
3.2.2 Choosing the right system 47
3.2.3 Waste reduction and recycling 48
3.2.4 Waste transport collection efficiency 50
3.2.5 Waste separation 54
3.2.6 Processing and preparation 54
3.2.7 Composting 55
3.2.7.1 Composting methods used 56
3.2.8 Anaerobic digestion 59
3.2.9 Thermal treatment 62
3.2.9.1 Combustion systems 63
3.2.9.2 Non-combustion systems 64
3.2.9.3 Energy recovery 64
3.2.10 Recycling 66
3.2.11 Landfill 67
3.3 Resource recovery efficiency and related health hazards 71
3.4 Household hazardous waste management 72
3.5 Determining waste characteristics for appropriate treatment 72
3.6 Environmental impact assessment 72

3.7 Sustainability of selected system 72
3.8 Converting waste into energy 73
3.9 Financial issues 73
3.10 Section summary 74
4. Data collection: Bangkok's municipal solid waste management 77
4.1 General description 77
4.1.1 Geographical and social context 77
4.1.2 Roads and transport 78
4.1.3 Economic data 78
4.1.4 Climatic information 79
4.1.5 Hydrogeological context 80
4.1.6 Seasonal aspects 80
4.2 Production of MSW 81
4.2.1 Waste production sources 81
4.2.2 Amount of waste produced 83
4.3 Collection and transport of MSW 86
4.3.1 Type of housing and economic activities 86
4.3.2 Collection and transport system 87
4.3.3 Waste collection vehicles and equipment 89
4.3.4 Transfer stations 89
4.3.5 Hazardous waste disposal 91
4.4 Formal recycling operations 91
4.5 Waste characterization; a necessity prior to decision-making 92
4.5.1 Scheduling and budgeting waste characterization 92
4.5.1.1 Waste characterization schedule 92
4.5.1.2 Forecasted equipment and personnel requirements 92
4.5.2 Preparation of the waste characterization 94
4.5.2.1 Selecting the sampling periods 94
4.5.2.2 Accuracy in measurements and the number of samples 94
4.5.2.3 Separation of the zones to be studied 94
4.5.2.4 Selection of trucks to be sampled 95
4.5.2.4.1 Verification of truck weight 96
4.5.2.5 Identification of characterization area 96
4.5.2.6 The sampling 96
4.5.2.7 Sorting 99
4.5.2.8 Accuracy of the results 104
4.5.2.9 Results of the characterization 104
4.5.3 Laboratory analysis 114

4.5.3.1 Selection of analysis to be conducted 114
4.5.3.2 Preparation of samples for analysis 115
4.5.3.3 Determination of humidity 116
4.5.3.4 Results of laboratory analysis 117
4.6 Laws and regulations 122
4.6.1 Waste disposal in Thailand 128
4.7 Treatment plant implementation procedure in Thailand 129
4.8 Social impact and implications 132
4.9 Limitations of findings 133
4.10 Section summary 133
5. Decision-making framework *136*
5.1 Developing a decision-making framework 136
5.2 Identification of specific objectives and priorities 137
5.3 Developing the decision-making framework 138
5.4 Gathering of necessary data 138
5.5 Specification of decision-making issues 139
5.5.1 The issues addressed in this framework are: 139
5.5.2 Utilization of analysis data and planning 168
5.6 Determination of objective evaluation criteria 168
5.7 Verification of information and confirmation of reliability 169
5.8 Section summary 169
6. Decision-making tool applied to Bangkok *172*
6.1 Development of the decision-making tool 172
6.2 Reliability verification of the decision-making tool 173
6.3 Bangkok data review 173
6.4 The decision making tool applied to Bangkok 178
6.5 Section summary 192
7. Summary and conclusions *194*
7.1 MSW management 194
7.2 MSW treatment systems, equipment and management procedures 195
7.3 Waste collection and disposal 199
7.4 Waste characterization and its importance 199
7.5 Income sources to municipalities 200
7.6 Decision-making framework and its applicability 200
7.7 The decision-making tool 201
Bibliography *202*
ANNEXES *212*
ANNEX I. Directive 2000/76/EC on incineration 213

ANNEX II. EU Landfill legislation 1999 235
ANNEX III. Kyoto Protocol 258
ANNEX IV. Montreal Protocol 280
ANNEX V. Thailand Public Health Act 1992 307
ANNEX VI FACTORY ACT 1992 320
ANNEX VII. Thailand notification 334
ANNEX VIII. Thailand Environment Act 338
ANNEX IX. Basel Convention 364

List of tables

Table 1 GNP per capita and waste generation in selected Asian Countries 10
Table 2 Waste generation rate per capita in Thailand 11
Table 3 Overview of waste characteristics in urban settings in tropical countries (% by weight) 12
Table 4 Composition of Urban Solid Waste in South Asia (in % by weight) 14
Table 5 Average waste composition for Thailand 15
Table 6 Waste composition in rural Thailand (not including large city centers) 15
Table 7 Recycling in Asian countries 17
Table 8 Correlation between Gross National Income (GNI) and waste generation in selected countries 35
Table 9 Disposal Methods for Municipal Solid Waste in Selected ASEAN Countries 48
Table 10 Different transfer technologies 53
Table 11 Summary of main composting methods used 57
Table 12 Estimated ranking for capital investment costs of MSW treatment 66
Table 13 Soil permeability levels according to EC regulations 70
Table 14 Climatic information according to the season 79
Table 15 Average rainfall and temperature for Bangkok 1999 79
Table 16 Aquifers in Bangkok Metropolitan areas 80
Table 17 Bangkok climatic conditions 81
Table 18 Waste production by source 83
Table 19 Increase in Bangkok population 1992 – 2015 84
Table 20 Sorting nomenclature of categories and subcategories used in France 99
Table 21 Results of waste characterization in Bangkok in kg on raw waste per category of large waste 105
Table 22 Results of waste characterization in Bangkok in kg on raw waste per category of medium waste 106
Table 23 Total waste characterized in % by wet weight and kg per category for Large and Medium waste 107
Table 24 Results of waste characterization in Bangkok in % by wet weight of total samples per Large category 108
Table 25 Results of waste characterization in Bangkok in % by wet weight of total samples per Medium category 109
Table 26 Categories of waste investigated 115
Table 27 Results of laboratory analysis for % of moisture content per category of waste 118
Table 28 Results from laboratory analysis for theoretical low heat value 120
Table 29 Results of laboratory analysis for % of volatile matter content for two selected categories 121
Table 30 Landfill classification in Thailand 124
Table 31 Physical distance from landfill sites for various structures 128

List of Figures

Figure 1 Regression analysis chart GNI Vs Waste generation per capita *36*
Figure 2 Comparative correlational chart *37*
Figure 3 Types of vehicles used for waste collection in various countries *51*
Figure 4 Basic principle of anaerobic digestion *59*
Figure 5 Energetic potential from biogas under different energy production systems *61*
Figure 6 Typical biogas power generation plant *62*
Figure 7 Thermal treatment-processing systems *63*
Figure 8 Items selected for recycling *67*
Figure 9 Map for location of Thailand *77*
Figure 10 Waste increase from 1985 – 2015 ..... *85*
Figure 11 Waste generated from 1994 - 2001 ..... *86*
Figure 12 Collection and transport organizational chart *88*
Figure 13 Landfill sites for Bangkok waste 2002 ..... *89*
Figure 14 Map of Bangkok City with its 50 districts *95*
Figure 15 Sampling procedure *97*
Figure 16 Example of coding on sorted samples *98*
Figure 17 Waste characterization diagram primary sorting *100*
Figure 18 Waste characterization diagram secondary sorting *101*
Figure 19 Quantity of large size waste per sample *110*
Figure 20 Quantity of medium size waste per sample *111*
Figure 21 Waste composition for medium and for large size waste in % by wet weight *112*
Figure 22 Waste composition for total quantity of waste in % by wet weight including residuals (fines) *113*
Figure 23 Humidity per category in % *119*
Figure 24 Calorific value of waste *120*
Figure 25 Volatile content by category in % *121*
Figure 26 Waste disposal sites around Thailand *129*

ABBREVIATIONS, ACRONYMS AND UNITS

AFNOR	Association française de normalisation
BMA	Bangkok Metropolitan Administration
BOT	Build Operate and Transfer
CBO	Community Base Organization
CH_4	Methane
CH_4S	Mercaptans
CNG	Compressed natural gas
CO2	Carbon dioxide
DIN	Deutsches Institut für Normung
DMT	Decision-making Tool
EC	European Community
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EU	European Union
EUR	Euros
FCA	Full Cost Accounting
GDP	Gross Domestic Produce
GHG	Green House Gas
GINI	Measure of inequality within a population
GNI	Gross National Income
H_2O	Water
H_2S	Hydrogen sulfide
HCl	Hydrochloric acid
HDPE	High density polyethylene
HHMSW	Household municipal solid waste
HHV	High heating value
HHW	Household waste
JBIC	Japan Bank International Corporation
K	Permeability / hydraulic conductivity
Kg	Kilogram
Km^2	Square kilometer
kW	Kilowatt
kWh	Kilowatt hour
Lb	Pound
LCA	Life cycle assessment
LDPE	Low density polyethylene
LEL	Lower explosive limit

LHV	Low heating value
m^2	Square meter
m^3	Cubic meter
mm	Millimeters
m/s	Meter per second
MSW	Municipal solid waste
MSWM	Municipal solid waste management
MV	Medium voltage
NEPO	National Energy Policy Office
NEQA	National Environmental Quality Act
NF	Normes françaises (French standard)
NGO	Non-Government Organization
NH3	Ammonia
NIMBY	Not In My Back Yard
Nm^3	Normal m^3 *(Normal, in this connection, means a temperature of 0 degrees Celsius and a pressure of 1.013 bar)*
PCD	Pollution Control Department
PCDD	Polychlorinated dibenzodioxins
PCDF	Polychlorinated dibenzofurans
PE	Polyethylene
PET	Polyethylene tetra
PHA	Public Health Department
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
Rai (one)	1,600 m2
RDF	Refuse derived fuel
SW	Solid waste
THB	Thai baht (Thailand local currency)
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNCHS	United Nations Centre for Human Settlements
USAID	United Sates Agency for International Development
USEPA	United States Environmental Protection Agency
USD	American dollars
WB	World Bank

1. Introduction

1.1. WASTE MANAGEMENT IN ASIAN TROPICAL CITIES

Asian countries are predominantly agriculture base and therefore, waste produced is mainly organic. Nevertheless, there are substantial differences between urban and rural lifestyles. For most countries, urban areas, especially the countries' capitals, emulate western lifestyles and therefore, the waste generated is close to what is found in western countries. For example, high content of paper, of plastics, and an overall higher quantity of waste generated daily. Moreover, numerous tourists visiting these countries usually go to city centers bringing with them their cultural and food habits, thus contributing to the similarities in the type of waste generated.

In rural areas, a large quantity of the organic waste is used as feed for pigs and other farm animals, while the remaining organic waste can easily be degraded and used in gardens as natural organic fertilizer. Other waste such as paper, glass, metals and plastic is not found in large quantities due to high levels of illiteracy, and limited financial resources to buy anything, whether made of plastic or not. Yet, changes in lifestyles, with an increasing amount of imported products, in a cash based consumer goods market, not only change the composition of waste but also demand new and improved disposal methods and techniques.

The feasibility and applicability of specific waste treatment systems in various cultures, climatic conditions, social acceptability, and environmental compliance need to be developed, introduced, and adapted to local needs and requirements. Choosing the appropriate system has been a growing concern and often a problem for public servants and administrators who are not necessarily engineers or experts in environmental management systems. To counter this problem, numerous models and decision-making tools have been developed over the years, each one offering a different approach to the problem of decision-making. Unfortunately, most of the models require computer expertise and the assistance of a technician or the reading and understanding of a several hundred pages technical guide written for the programme. Ranging from science to social development, these models offer more or less flexibility in their data processing, and the majority require in depth understanding of the computer programmes, thus eliminating all person who is not proficient in computer technology, eliminating the person responsible for selecting the appropriate MSWM system, the public administrator.

The problem of selecting an appropriate system is further compounded by local conditions and constraints. The quantity and quality of waste found in tropical Asian cities if quite different from those of the western world. The high populations in Asia is a well-known fact where even in the remote villages, one can count several hundred inhabitants. Thus, the selected waste treatment must be able to cope with the amount of waste and take into consideration the increase in population. Another issue, which is highly problematic in those countries, is the level of humidity in the waste. During monsoon seasons especially, waste becomes drenched in water and therefore technologies such as incineration become prohibitively expensive, requiring a drying pre-treatment. The efficiency of a treatment system is also key to health conditions in

these cities. The humidity combined with high temperatures become a haven for vermin, insects and the proliferation of bacteria, either through direct contact, or through water spreads and even airborne. Although western countries have hot temperatures during summer time, winter temperatures kill many of the nuisances and therefore allow nature to renew itself at least once a year. Moreover, the volume of waste is lower hence easier to handle.

The difference between western MSW and that from Asian tropical countries is therefore significantly different and requires careful verifications prior to selecting the appropriate waste treatment system.

1.2. PURPOSE OF THE DISSERTATION

The purpose of the dissertation was to develop a decision-making tool, which is to be used by public administrators and government officials, in the selection of the most environmentally, economically, and socially appropriate MSW treatment system for the community. Although several such tools have been developed, majority of them are complex and require special training for which most officers lack the time and often the computer skills to learn. This decision-making tool is to use a series of questions while the data analysis was written in excel base programming, which is well known and understood by all computer users, and therefore is to be user-friendly for public administrators and environmental officers. Utilizing a decision-making framework developed based on a comparative approach of six waste treatment systems, the framework takes into consideration local needs, constraints and objectives, both short term and long terms, and allows the decision-maker to identify the most technically, economically and socially appropriate MSW management system for the local community.

The framework is the basis for the tool developed for decision-makers, as to guide them through the various issues that are necessary in the selection of an appropriate and sustainable waste management and treatment system. Tropical Asian cities must consider a number of issues when deciding on their waste management plan such as the continuously changing quantum and composition of waste associated with the increasing population and income per capita, the high humidity levels, and the often-limited financial resources. Other determinant factors include legal, political, institutional, social, and technical issues. Furthermore, administrators must realize the importance of each stage involved in waste management, which includes waste generation, collection, transport, composition, disposal and treatment, their implication on the community's well being and their impact on the environment.

To better understand the complexity of the issues involved in Asia's waste management, the city of Bangkok, Thailand's largest city and capital was selected as a case study for the management of its 9,000 tonnes of waste generated daily. Numerous interviews, meetings along with the review of documents, reports and site visits offered an inside view of the tropical city's various decision-making issues towards its waste management plan, and examine specific problems encountered by the city's decision-makers. The review and analysis of the decision-making issues involved in Bangkok's waste management plan confirm the importance of the identified decision-making framework issues, which need to be used in the various Asian tropical cities.

1.3. RESEARCH METHODOLOGY

In order to verify that the decision-making tool was well adapted to tropical climate conditions, and that it answered to all of the municipality's concerns, the municipality of Bangkok was selected as one of the most representative cities. Bangkok was most suitable because of the country's overall advancement as an emerging country, while maintaining a rural life similar to many of its poorer neighboring countries. Although Bangkok was the focus of the dissertation, the concern for rural MSW management remained present and therefore, the tool had to allow flexibility for the users and answer to the needs of rural communities. Finally, the tool had to allow other communities in need of an appropriate MSWM system to use this tool successfully.

The methodology for the development of the decision-making tool used both theoretical and practical approaches, as per the following steps:

- Identification of decision-making determinant issues
- Review of literature as to verify existing computer programmes and the key issues involved in their software.
- Development of a decision-making framework based on these issues
- Verification of framework issues through meetings and interviews organized with central and municipal government officers as to validate and complete required data.
- Collection of data from the city of Bangkok based on the required issues from the framework.
- Verification through meetings and visits with private operators to validate and complete information received from government officers.
- Design of a questionnaire using closed questions, and their entering into an Excel base decision-making programme.
- Valuation of each answers to each questions, each value ranging between zero and one, depending on number of possible responses.
- Self-ponderation of the questionnaire, using the number of sub-questions or repetition of a same question or equivalent questions as the pondering value.
- Testing of model with the information gathered from the Bangkok municipality
- Analysis of results and comparative review of findings with those in the field evaluation for the most appropriate treatment system made by engineers, as to confirm the workability of the tool.

The decision-making tool uses an Excel base spreadsheet programme, as to facilitate its use. The spreadsheet has been recognized as a useful tool for teaching, simulation, and design of prototypes. Seal et al (2000) made a research on the spreadsheet and found 172 papers with spreadsheet models defined and implemented for clients and another group to address problems or issues raised by researchers. A large number of the first group

implemented decision support systems or mathematical programming tools are spreadsheets. It was therefore concluded that the spreadsheet is a legitimate modeling tool. Moreover, it is a programme that is known and utilized by all Microsoft office users and therefore requires no supplemental learning and training skills. The users can simply open the programme, supply the requested information in the spreadsheet, and read the results in the analysis review. This excel base spreadsheet programme is meant as a tool for decision-makers and as such, has been made user-friendly to allow government officers and non-experts an evaluation of the integrated waste treatment system for their community, and a tool to assist in the selection of a technically, economically feasible and socially acceptable integrated MSW management system.

1.4. ORGANIZATION OF THE DISSERTATION

The dissertation is divided into seven sections.

The first section presents the problem of MSW management in Asian tropical countries, the purpose of the dissertation, the methodology used to gather information and for developing a decision-making framework, and the organization of the dissertation.

The second section is a review of literature that gives an overview of several comprehensive studies that were conducted on Asian environment. More, specifically, it looks at the role of local communities in decision-making, sustainable MSW management and its various techniques, the use of fuzzy logic for decision-making, the process involved in decision-making, and a review of some of the existing decision-making tools and software.

The third section identifies the key issues involved in MSW management, and analyses each of them and their impact on the decision-making process.

The fourth section is a compilation of data collected and revised from the city of Bangkok. This data is to be used as a reference for the decision-making tool as an example of an Asian tropical city.

The fifth section explains and justifies the decision-making framework used, by reviewing all information needed to properly assess the most appropriate waste treatment process for a specific community, according to the type and quantity of waste, to the political and social develop plans of the community and to the financial constraints generally present, especially in small communities.

The sixth section introduces the decision-making tool, shows how it was utilized for the study of the city of Bangkok, and how it can be used for other municipalities.

The seventh section summarizes findings and presents the conclusions of the dissertation.

1.5. SECTION SUMMARY

The purpose of this dissertation was to develop a decision-making tool based on a decision-making framework prepared from the most important issues involved in decision-making in the selection of the most appropriate and sustainable waste treatment system for its municipality. This tool is to take into account the social and political implications of the municipality. It also takes into consideration the type of waste, its humidity, its calorific value, and waste treatment systems that are acceptable to the local government and to the local population.

The methodology was both theoretical and practical. First, decision-making determinant issues were identified. A review of literature was conducted followed by interviews and data collected from the municipality of Bangkok as to verify that all key issues had been addressed. Then came the preparation of a decision-making framework based on the identified issues. From this was developed the decision-making tool. The data collected from the city of Bangkok allowed a verification of the workability of the tool.

The whole dissertation is separated into seven sections, the first being the purpose of the dissertation; the second the review of literature; the third identified the key issues; the fourth a compilation of data collected from the city of Bangkok; fifth, the decision-making framework; sixth, the decision-making tool; and seventh and last section, the summary of findings and conclusions.

2. Review of literature

2.1 THE ASIAN ENVIRONMENT

Countries around the world have undergone major changes in their communications and transportation facilities with high-speed transport, instant on-line communications, and frequent flying from one continent to the other. Asian countries are no different yet alongside these global changes came rapid economic growth with a rise in population, migration from rural areas to cities, and overall population displacements. Although GNP is increased, a majority of people in Asian countries are living on minimal income and therefore seeking a better quality of life for themselves and their family, thus creating an exodus to larger cities. Hence, the squalor, slums, traffic congestion, and shortage of water and power are typical in Asian urban cities [Adbi 1999]. Yet most Asian countries remain predominantly rural and agriculture base. In 1997 came the economic crisis in Asia, and therefore a rapid decline in foreign investments, which lead to a general recession felt at all levels of governments. Notwithstanding, governments in Southeast Asia have undertaken many national initiatives towards environmentally sustainable development. These include the creation of special institutions that are moderately advanced and in adequate numbers, the development of laws and legislation, the use of economic instruments and the development of links with the private sector, which is still in early development stage [UNESCAP 2001].

The World Bank estimates the cost of Southeast Asia's environmental degradation to be approximately five percent of its GDP and the cost of pollution abatement per life saved at US$ 1,000 or less [UNESCAP 2001]. Overall, urban areas have an impact on the environment through the conversion of land into urban use, the extraction and depletion of natural resources and the disposal of urban waste [UNEP 2001]. In order to improve municipal waste management, exchange of information and experience on urban governance must be encouraged. Overall, economic development is the responsibility of the national government whereas local governments must manage the rapidly growing urban areas and provide basic and necessary services for their residents. These challenges must take into consideration the limited resources and capacities of local governments [Hamid et al, 1999]. Therefore, partnership with other stakeholders may minimize the costs associated with planning and implementation strategies. Moreover, with the global decentralization efforts, local governments have increasing responsibilities for the management of their water supply, sewerage, and for the transport and disposal of waste within their community. The power is still tacitly within the hands of the central government while local governments are expected to tackle the problems associated with urban and environmental planning with the community. There is constant change and evolution between national and local governments in the balance of power and distribution of duties [Mehta et al 1998]. Financial resources are also limited and contingent to the approval of central government officers. This creates discrepancies and reduced efficiency for governments to tackle environmental problems. This can be further confirmed by a statement of Mayor Phummisak Hongsyok of Phuket Island in Thailand, who confirmed that the island, which is almost the size of Singapore (543 km^2 Vs. 682 km^2 respectively), was losing its main source of income, tourism, because of environmental deterioration. Therefore, starting 1994, the Mayor initiated an urban

environmental management programme by developing a collective vision, and gaining the support from the business community, and from the local NGOs and communities [Hamid et al, 1999].

Municipal solid waste management is the responsibility of local governments since it is necessary to ensure public health and environmental protection. Unfortunately, until this day, and in many localities in developing and emerging countries, MSW is not given appropriate attention or concern, often placing waste management at the bottom of the list of priorities. This is especially true for Asian countries where wild landfills are still common and where decision-making is often hampered by political ambition and greed. Moreover, in tropical environments, the characteristics make waste treatment and disposal especially challenging, with an especially high level of humidity. Appropriate selection of a decision-making tool can therefore be most useful in order to assist in the selection of the most appropriate and feasible MSW management and disposal system.

2.2 THE ROLE OF LOCAL COMMUNITIES IN DECISION-MAKING

Governance must take into consideration three main stakeholders namely the state, the private sector, and the civil society. The state (which may include the central, provincial or municipal government, the city council…) is necessary to create a conducive political and legal environment; the private sector (including private informal and formal sectors, service users…) generates employment and income. The civil society (which includes NGOs, CBOs) facilitates political and social interaction with groups participating in economic, social and political activities. Each group has its strengths and weaknesses and therefore, close interaction and exchange between the three groups is necessary [Hamid et al 1999]. Other stakeholders may include donor agencies that require the right to review the outcome, and the technical and cost efficiency of the project to which they have pledged funds. Moreover, good governance requires accountability by public officials, which in turn reduces corruption and assure citizens that their Government's actions are in answer to the needs of the people [Mehta et al 1998]. MSW management needs comprehensive national policy in order to provide the required framework for environmental and health protection. Municipalities need to prepare long-term management plans along with implementation and enforcement strategies, and be capacitated to efficiently and feasibly plan, finance, operate and maintain a waste treatment plant. This is where cooperation and exchanges between local municipalities encourage the sharing of information and experience. Public participation through contractual arrangements for waste collection, segregation, and disposal can also facilitate enforcement measures. Proper capacity building is required in most Asian local communities, to explain to decision-makers the various technical and social aspects associated with MSW management techniques. Training should also prepare for the usually required environmental impact assessment, public hearing, and the required potential need for conflict management, public participation and negotiations towards a final and appropriate decision-making. The faith of waste-pickers must also be considered in MSW management strategy since for many, MSW is a source of raw materials, which ensures their livelihood. Planning should therefore include the participation of the waste-pickers and various levels of the MSW collection, management and disposal plan. Some options may include house-to-house collection and manual segregation of waste prior to final disposal, which would show appreciation towards the positive contribution of waste-pickers and scavengers to the reduction of

waste to be collected and disposed of by local authorities. This is especially true in Asian cities, which number tens of thousands of waste pickers [UNCHS, 1991].

2.3 DECISION-MAKING FOR SUSTAINABLE MSW MANAGEMENT

Decision-making involves changes in existing facilities or in management procedures. It therefore involves the selection of new or modified systems, or facilities that meet modern environmental, economic and social standards. Waste management is not only the transformation and disposal of waste. It is also about collection, collection routes, equipment, and recycling. The implication is therefore a change in the composition of the waste to be disposed of. Therefore, the collection of waste, its transformation and final disposal must take into consideration waste reduction at source and the renewal of recyclable materials.

During the mid 1990s, the amount of waste produced in South-East Asia alone was estimated at 700 million tonnes per annum [UNEP, 2001]. This amount is increasing and the problem is compounded by the fact that high temperatures and heavy rains are the perfect breeding grounds for bacteria and associated diseases. It is therefore necessary to deal with MSW in an efficient, feasible and sustainable manner through appropriate waste management strategies, which must not only include technical issues but also take into consideration political, institutional, social, financial, socio-economic and environmental aspects [Schübeler et al, 1996]. As such, decision-making must be based on a complete, extensive and comprehensive set of all data collected within the locality. The focus must always be on the impact of action on poverty alleviation, environmental protection, human rights, equality and good governance. The achievement of these objectives can then be reviewed and evaluated to verify their effectiveness, expediency, economic efficiency, impact and sustainability of action [Finland, 1999]. Moreover, the quantity of waste generated per capita along with the major changes in industrial activities in Asian cities resulted in a proportional increase in consumption. Consequently, there was also a change in the volume, characteristic and complexity in the waste composition generated [UNCHS, 1991]. For example, the high level of plastic in cities such as Bangkok is typical of local customs where there is food everywhere and 24 hours a day, most of it served in plastic bags. The quantity and type of waste generated is overall directly related to the level of income. The following table shows the correlation between the levels of income, the quantity and the type of waste generated.

Table 1 GNP per capita and waste generation in selected Asian Countries

Country	*Current*					*2025*				
	GNP Per Capita 1995 US$	*1995 Population*		*Urban Waste Generation*		*Predicted GNP per capita US$*	*Predicted Population*		*Predicted Urban Waste Generations*	
		Total[1] (millions)	*Urban[2] (% of Total)*	*Generation Rate (Kg/cap/d)*	*Total Waste (tonnes/d)*		*Total[2] (millions)*	*Urban[2] (% of Total)*	*MSW (kg/cap/d)*	*Total (tonnes/d)*
LOW INCOME COUNTRIES										
Nepal	200	21.50	13.70	0.50	1,473	360	40.70	34.30	0.60	8,376
Bangladesh	240	119.80	18.30	0.49	10,742	440	196.10	40.00	0.60	47,064
Myanmar	240[3]	46.53	26.20	0.45	5,482	580	75.60	47.30	0.60	21,455
Vietnam	240	73.50	20.80	0.55	8,408	580	118.20	39.00	0.70	32,269
Mongolia	310	2.50	60.90	0.60	914	560	3.80	76.50	0.90	2,616
India	340	929.40	26.80	0.46	114,576	600	1,392.10	45.20	0.70	440,460
Lao PDR	350	4.90	21.70	0.69	734	850	9.70	44.50	0.80	3,453
China	620	1,200.20	30.30	0.79	287,292	1,500	1,526.10	54.50	0.90	748,552
Sri Lanka	700	18.10	22.40	0.89	3,608	1,300	25.00	42.60	1.00	10,650
MIDDLE INCOME COUNTRIES										
Indonesia	980	193.30	35.40	0.76	52,005	2,400	275.60	60.70	1.00	167,289
Philippines	1,050	68.60	54.20	0.52	19,334	2,500	104.50	74.30	0.80	62,115
Thailand	2,740	58.20	20.00	1.10	12,804	6,700	73.60	39.10	1.50	43,166
Malaysia	3,890	20.10	53.70	0.81	8,743	9,440	31.60	72.70	1.40	32,162
HIGH INCOME COUNTRIES										
Korea, Rep. of	9,700	44.90	81.30	1.59	58,041	17,600	54.40	93.70	1.40	71,362
Hong Kong	22,990	6.20	95.00	5.07	29,862	31,000	5.90	97.30	4.50	25,833
Singapore	26,730	3.00	100.00	1.10	3,300	36,000	3.40	100.00	1.10	3,740
Japan	39,600	125.20	77.60	1.47	142,818	53,500	121.60	84.90	1.30	134,210

Sources: 1 World Bank, 1997b; 2 United Nations, 1995; 3 assumed GNP Country waste generation rates are based on weighted averages from different cities within the country Source, World Bank, 1998

One can see that there is a directly proportional correlation between the GNP and the quantity of waste generated per person per day. This proportion, however, changes from low-income countries and high-income countries. In the low-income countries, the higher the income, the more the quantity of waste per capita. However, this tendency is reversed in high-income countries due to appropriate MSWM planning, and to often well implemented recycling programmes. Finally, cultural habits, traditions, and urban or rural dwellings play key role in the type and quantity of waste generated.

The following table shows the differences in the quantities of waste generated in various cities around Thailand.

Table 2 Waste generation rate per capita in Thailand

Location	Generation Rate (kg/cap/day)
Thailand average	0.65
Urban Areas	0.40 – 1.90
Bangkok	1.30
Khon Kaen	1.00
Ranong	0.70
Chanthaburi	0.60
Kantchanaburi	1.30
Rural areas	0.40 – 0.60
Pattaya, Chonburi	1.60
Patong Beach, Phuket	5.00

Source: Thailand Environment Monitor 2003, written by PCD in collaboration with USAID, JBIC and WB.

Note: PCD 2001 data includes solid waste produced by all sources, normalized to the registered population as non-registered was not available. Bangkok population, through personal communication with JBIC, 2000 includes non-registered population. It should be noted that Bangkok waste generation should be 1.6 kg/capita/day for registered populations only.

The above numbers somewhat differ from the GNP table as the cities used as reference may vary according to the studies. Thailand is a very diversified country that includes highly developed cities and poor rural areas. Bangkok is an especially complex city in terms of MSWM because of its diversity of people, economic *strata* and especially, because of the high number of people living in the city, and the difficulty associated with the number of registered and non-registered people living in the city, which include, migrants from rural areas and tourist. The shortage of available space in proximity of the city and the extreme climatic conditions ranging from drought to rainy seasons also offer a challenge for any treatment plant, changing drastically the characteristics of the waste.

The following table compares eight tropical Asian countries and their waste characteristics.

Table 3 Overview of waste characteristics in urban settings in tropical countries (% by weight)

City	% Biodegradable	% Paper	% Plastic	% Glass	% Metal	% Textiles & Leather	% Inert materials (ash, earth, others)
Bangkok[1]	53	9	19	3	1	7	8
Dhaka[2]	70	4.30	4.70	0.30	0.10	4.60	16
Hanoi[1]	50.10	4.20	5.50	0	2.50	0	37.70
India[4]	42	6	4	2	2	4	40
Indonesia[5]	74	10	8	2	2	2	2
Karachi[3]	39	10	7	2	1	9	32
Kathmandu[1]	68.10	8.80	11.40	1.60	0.90	3.90	5.30
Manila[6]	49	19	17	0	6	0	9

1 (UNEP, 2001), 2 (Kazi, 1999), 3 (APE, 2001), 4 (Akolkar, 2001)5 (Walhi, 2001), 6 (World Bank, 2001)

The above table shows that the average quantity of biodegradable waste can be estimated at 50% with the highest level in Indonesia of 74% and the lowest level in Karachi with 39%. The methodology used for the characterization of waste would certainly clarify the large discrepancy between the two countries. However, one can see that in Karachi, 32% of the waste is considered as inert materials and other materials. This could account for a lot of the waste being burned in open air as a disposal method often locally used in developing countries.

It must be noted that there is increasing awareness and interest for recycling. Therefore, it is safe to assume that although the quantity of waste produced may be *defacto* increasing, a fair proportion of it will not appear into the waste stream but rather forwarded towards recycling, thus it may be possible to assume that there shall be no changes in waste generation. Future projections should therefore be based on population projections alone [USEPA 1995].

In most countries in Asia, except for a country such as Korea where there is a voluntary selective waste sorting, waste is thrown away inconsiderately. In low-income areas and squatters, collection of waste is not always ensured. Moreover, certain areas with only small lanes and little accessibility do not allow collection trucks to enter the areas. One can see this in many areas in Vietnam, where waste is collected using bicycles and tricycles that bring the waste to a truck parked at the end of the street, since it cannot enter the narrow lanes.

By considering their citizens as consumers and therefore shifting their focus on customer orientation, municipal organizations could better answer to citizens' demands, improve local services and recover the cost for the provision of municipal services [Hamid et al, 1999]. Community members must understand that environmental protection and sanitation is everybody's responsibility. In order to ensure that all people understand, it is necessary to involve the people through community activities. If the people participate in the protection of the environment and in the prevention of its deterioration, they will be motivated to continue once they return to their homes.

In many countries, legislation has been established with the objective of protecting the environment. Unfortunately, enforcement measures were not properly developed or just non-existent. Appropriate monitoring and evaluation schemes need to be further developed as to ensure that legislation is enforced.

2.4 MSW MANAGEMENT TECHNIQUES AND VALORIZATION

Waste management involves various steps, which can be utilized in the treatment of municipal solid waste. Therefore, several approaches or techniques can be used. For example:

- Waste minimization
- Waste re-use
- Waste recycling
- Waste collection
- Waste transportation
- Waste treatment
- Waste disposal

An appropriate waste treatment system generally involves at least three of the techniques mentioned above. At a minimum, waste should always be collected and transported to the transfer station or treatment and disposal site.

2.4.1 CHOOSING THE RIGHT SYSTEM

According to the United Nations' Center for human Settlements (1991), it is estimated that by the year 2020, an additional 1.5 billion people will be added to Asia's urban centers. This will add to the problem of land scarcity in Asian countries making landfill an obsolete waste management technique. Laws in most countries around the world now require some treatment towards the reduction of the volume of waste, and the quasi-elimination of organic matter to be sent to landfill in order to reduce or eliminate landfill-gas production and potential contamination of soil and groundwater associated with landfill leachate.

Incineration was promoted in Asia for the destruction of MSW disposal. Unfortunately, incineration gained a bad reputation. Over the years, people have built small and larger incinerators with ineffective or inexistent air pollution control systems, thus allowing the release of dioxins and furans into the atmosphere. A highly performing air pollution control system can certainly control the spread of pollution much more than landfill. Yet, it is very costly and therefore, many buyers do not wish to pay for the control of some emissions that contain pollutant they cannot see. Moreover, the operating costs of incineration have been known to be very high because of the high level of moisture contained in MSW, problem compounded in the tropical countries during the rainy season.

The fact remains that in tropical Asian cities, due to the high density of people and populations, the quantity of waste generated is very high. Moreover, the quantity of rainfall and level of humidity increases the leachability of waste into the ground and groundwater when landfills are not secured by protective membranes. This climate, however, is a perfect facilitator for accelerated biodegradation. This is the reason why composting has been promoted in these regions and for many, compost remains a proper disposal method. Composting is in fact, Mother Nature's way of dealing with organic waste. Nevertheless, several composting plants were shut down following a few years of operation because the market could not absorb or use the produced compost. Some explanation for this was that the quality of compost was often below standards containing a high percentage of impurities such as glass and plastic, or the compost was not mature enough and therefore created some skin irritation when in direct contact. Another reason was economical; the price of compost was higher than for the commercial fertilizer or soil conditioner.

Overall, management and disposal techniques must take into consideration the quantity and composition of waste. In a study conducted by World Bank, the average solid waste composition in selected Asian countries can be summarized as follows:

Table 4 Composition of Urban Solid Waste in South Asia (in % by weight)

Country	**Nepal**	**Bangladesh**	**India**	**Sri Lanka**
Type of waste	**(MSW)**	**(Domestic)**	**(MSW)**	**(Domestic, commercial)**
Compostable	80.00	84.37	41.80	76.40
Paper	7.00	5.68	5.70	10.60
Plastic	2.50	1.74	3.90	5.70
Glass	3.00	3.19	2.10	1.30
Metal	0.50	3.19	1.90	1.30
Others	7.00	1.83	44.60	4.70

Source: World Bank Urban Development Sector Unit, Solid Waste Management in Asia (1999)

Table 5 Average waste composition for Thailand

Type of waste	Percentage of fraction by weight
Fruits, vegetables, food	31 %
Plastics	22 %
Paper and cardboard	9 %
Leaves and wood	10 %
Textiles	4 %
Glass	4 %
Metals	2 %
Others	18 %

Table 6 Waste composition in rural Thailand (not including large city centers)

Composition	% in Wet Weight
1) Fruits, vegetables and food	56.08
2) Plastic	16.33
3) Paper and cardboard	9.11
4) Rubber	1.00
5) Leather	0.25
6) Textile	1.87
7) Wood and leaves	5.10
8) Glass	5.12
9) Metal	3.11
10) Miscellaneous	2.03
Total	100.00
Bulk density, kg/m3	225.40

These two table clearly show the difference between the composition of waste within a same country, where the organic fraction is much higher in rural areas. Nevertheless, because it is food-scraps and market waste, this does not mean that it can be used for composting. The fact is that people in rural areas feed the pigs and chicken with this waste and therefore, this cannot necessarily be used for composting. Care must be taken

when evaluating a disposal or re-use option, as to availability and composition of raw materials.

2.4.2 MSW COLLECTION

Waste collection is an important and costly operation involving specifically designed vehicles, equipment and labor. In the western world, waste collection has been automated replacing workers by mechanical lifting systems for emptying the bins. It is estimated that 50 – 70% of all solid waste system expenditures are for collection [Tchobanoglous, 1993]. Notwithstanding, in developing and emerging countries, not only is the automated solution not feasible because of the low labor costs, but also such changes have a direct impact on the livelihood of thousands of people who are counting on recyclable materials as a main source of income. The issue of health and safety is therefore compromised by income generation through waste picking and sorting practices. Moreover, waste diversion such as waste reduction at source and recycling have a direct impact on waste transformation and disposal of waste. Unfortunately, some countries do not collect much waste. Such is the case in Pakistan, where the municipality only collects 18% of the waste while 45% is collected by a private organization [Finpro, 2004]. Waste collection ordinance is crucial to ensure appropriate and maximized waste collection practices. Additionally, there can be policies regarding collection, waste reduction and recycling practices. This in turn will require an increase in income, generally through taxes, to pay for the service.

Collection operations are ensured by public or private organizations, depending on the locality and existing laws and regulations, which are established by local and central government agencies. Private organizations are often contracted to collect the waste. Three typical types of contractual agreements can be mentioned:

1. Franchise: Used to maximize service and collection efficiency through the identification of specific geographic boundaries. Moreover, stability in contractual agreement encourages investment in better and more appropriate equipment.

2. Limited permits: Used when costs are an issue. These permits often limit competition. However, without the specific boundaries, collection efficiency may be reduced.

3. Unlimited permits: For total competitiveness. Contractors can set their own rates. There is however danger of overlapping routes, hence a reduction of collection efficiency with some areas that may remain uncollected, and the failure of some waste collection companies.

The composition of waste, its collection and disposal varies from one country, and from one part of a country to another. The most common issue is certainly the irregularity of collection, which varies from 20% to 90% of the total quantity of produced municipal waste [UNEP, 2001]. Climatic and weather conditions are determinant factors in the collection of municipal waste. In some countries, for example in India, waste bins are open whereas in Thailand, they are generally closed, leaving a less environmental distressing stench in the surrounding.

Although strategic planning needs to be established, certain actions should be promoted in order to make the people aware and responsible for the management of MSW. According to Hamid (2000), these actions include:

- Community involvement
- Separation of garbage in color coded bags
- Strict enforcement with on-the-spot fines
- School education
- Informal education through street plays
- Publicity campaign on the "green city"
- Involvement of the private sector

Transportation from collection to disposal site should be minimized. Because of land shortage, transfer stations are often used as a central waste collection point, the waste is then hauled by large lorries to distant incinerators or landfills. Nevertheless, long distances increase the dangers of contamination on the way, increase the impact of traffic and related air-pollution, and costs associated with transport.

2.4.3 VALORIZATION THROUGH RECYCLING

Recycling waste may or may not be the feasible solution for a community, although it is highly promoted by environmental programmes. Comparative reviews need to be undertaken as to evaluate the most feasible solution. For example, the separation and removal of plastic in MSW before sending it for incineration drastically reduces the calorific value of the waste and therefore may render incineration and waste-to-energy techniques non-feasible. Moreover, the costs of goods made of recycled materials are often the same if not higher priced than those made of new materials, thus reducing the interest for recycling by certain manufacturers. Recycling can be a source of income for the community and/or the treatment plant, and will contribute to the reduction of the quantity of waste to be treated.

Table 7 Recycling in Asian countries

City	MSW recycled % by weight
Hong Kong	36%
Seoul	45%
Singapore	39%
Manila	13%
Bangkok	15%
Beijing	<10%

Source: Source: Thailand Environment Monitor 2003, written by PCD in collaboration with USAID, JBIC and WB.

2.4.4 VALORIZATION THROUGH COMPOSTING

Composting or the conversion of biodegradable waste into soil conditioner is a technique commonly used to reduce the volume of waste, while converting it into a product that can be used or sold as soil nutrient. Its content in nitrogen (N), phosphorus (P) and potassium (K) is not high and therefore, it is often used as filler in association with the NPK required for agriculture. The transformation of organic biodegradable waste into compost further reduces the green gas effects associated with methane production when this waste is sent to a landfill.

The economic value of the compost will be determined by its quality and purity. More specifically, it will be determined by its NPK content, the particle size and uniformity of particles, the extent of contamination with glass and plastics, and its freedom from pathogens and toxic organics and metals [DIAZ, 1996].

2.4.5 VALORIZATION THROUGH ENERGY PRODUCTION

Combustion and other thermal treatments of waste can generate energy using two basic approaches: directly by burning the waste as fuel to produce steam and heat, or indirectly by converting the waste into fuel, such as oil and gas, and fuel pellets or charcoal. Before deciding on its effectiveness, it is necessary to verify the suitability of waste as fuel. Then, it is possible to select the most appropriate energy production and recovery system; identify a buyer for the energy; develop a health safety and environment mitigation plan; secure a site and/or technology for the disposal of ultimate waste produced by the system (i.e. slag, ashes…); ensure that the selected system is within acceptable budget for the local community; and that it is environmentally friendly.

2.4.6 LANDFILLING, A NECESSITY IN DEVELOPING COUNTRIES

Landfilling remains a necessary disposal technique, until technology has developed feasible methods of complete elimination. Yet in Asia, land is becoming scarce with cities expanding in population and size. Open dumpsites, although still in existence in most countries in South Asia and Southeast Asia, are increasingly regulated and unauthorized. This is mainly due to the direct consequence of leachate and other pollutants that contaminate land and groundwater. Open landfills are also a source of nuisance with foul odor, insects and rodents, which are responsible for spreading diseases such as cholera and dengue fever, and a high-risk area for waste-pickers who are exposed to various hazardous materials, and to fires and explosions during their waste selection. In some countries, leachate from landfill is allowed to enter surface waters in nearby streams or rivers. Serious illnesses can develop when such contaminated water is used for bathing, cooking, irrigation and drinking. The most negative impact of a landfill on environment is the production of landfill gas, which is known for its impact on ozone depletion. This greenhouse gas is generated by the decomposition of organic waste that has been disposed in landfills without prior treatment. Countries such as Germany do not allow the disposal of organic materials to enter landfills without treatment, because of the nuisance and potential harm on air, soil and water pollution.

2.5 THE DECISION-MAKING PROCESS

Several factors influence the decision for cost effective MSW management. There should be a careful balance between the technically most desirable option and the availability of funds since substantial financial resources are required for conventional large-scale waste collection, transport and disposal technology [Bidlingmaïer, 2003]. UNDP (1998) has identified nine key elements for good governance. These are: participation (which includes public, institutional and private participation); rule of law (compliance with existing standards and legal framework, law enforcement), transparency (local and central government regular communication with population), responsiveness (to community needs, demands, request for information…); consensus orientation (between local communities and governments), equity (to all communities at all levels of social levels), effectiveness and efficiency (in attaining goal and objectives); accountability (through the selection of the most appropriate technology and its feasibility); and strategic vision (leaving room for expansion and upgrading for the future, and integration of the selected system to the municipality's strategic yearly development plan).

Moreover, several aspects need to be considered in a conceptual MSW management framework. These include political aspects, technical aspects, financial aspects, economic aspects, institutional aspects, social aspects and technical aspects. Schübeler et al (1996) define these aspects in the following way:

Political aspects *concern the formulation of goals and priorities, determination of roles and jurisdiction, and the legal and regulatory framework*; these aspects are driven by community and governmental leaders. Laws are developed to answer to the specific needs of the community, and for the social and environmental welfare. However, decisions are often driven by popularity and the need to be elected/reelected. Moreover, budget allocation is generally limited and therefore priorities are often on high-profile projects rather than environmental protection.

Institutional aspects *concern the distribution of functions and responsibilities, and correspond to organizational structures, procedures, methods, institutional capacities and private sector involvement*; these aspects have a direct impact on project implementation, maintenance and follow-up. Detailed task descriptions and distribution are necessary to ensure successful project implementation, may they be environmental, civil or other.

Social aspects of MSWM *include the patterns of waste generation and handling of households and other users, community-based waste management and the social conditions of waste workers*; the quantity and quality of waste is directly related to socio-economic aspects and cultural habits. The higher the income the higher the quantity of waste produced. Moreover, in rural areas, food waste is often recycled as animal food and therefore little food fractions are found in the rural community's waste. In certain countries, waste pickers work and often live on municipal "dumps" as to ensure their survival and the income necessary for the whole family. This issue becomes crucial when laws are implemented barring access to the dumps for the waste pickers, thus removing the only livelihood of hundreds if not thousands of families.

Financial aspects *of MSWM concern budgeting and cost accounting, capital investment, cost recovery and cost reduction*; financial aspects remain the primary issue in MSWM. Most implemented projects are not self-sustainable and therefore an annual budget for operation and maintenance is required, this in addition to the initial purchase and start-up cost. The higher the technicality, the higher the price. This is the reason why in developing countries, or those emerging nations where labor costs remain very low, it is more cost effective to install labor-intensive systems rather than fully automated waste treatment plants. However, the financial allocation must take into consideration the efficient air pollution control where applicable, and also safe and hygienic procedures for workers as to ensure their health and safety.

Economic aspects *of MSWM are concerned with the impact of services on economic activities, cost-effectiveness of MSWM systems, macro-economic dimensions of resource use and conservation, and income generation. A* well selected system will not only resolve the problem of waste management but will also generate income for local populations while taking into consideration the use of natural resources such as fossil fuel in its operation. A high cost plant may not offer cost-effectiveness and income generation. Local needs must be evaluated prior to decision-making.

Technical aspects *of MSWM are concerned with the planning, implementation, and maintenance of collection and transfer systems, waste recovery, final disposal and hazardous waste management*; a review of locally available technical personnel will contribute in determining the system's acceptable technical complexity. If the system is too complex, operation and maintenance needs to be ensured by outside personnel and experts, rendering the plant non-feasible. Moreover, the final disposal of ultimate waste along with the management and disposal of hazardous waste must be foreseen in a proper waste management plant. Hazardous materials such as halogenated chemicals, used oils and solvents, as well as fly and bottom ashes in case of incineration, need to be stabilized and disposed in an environmentally friendly method using the best available technology.

Van de Klundert (2000) adds environmental and socio-cultural aspects as to ensure the sustainability of waste management. In fact, both environment and socio-cultural aspects are included in Schübeler's aspects as part of each of the aspects. Nevertheless, it may be wise to mention these specifically as to ensure that aspects such as political or financial do not take dominance on the decision-making process.

Once a decision has been made, while considering every aspect, the selected management plan is to be included into a master plan. Models and variables should be reviewed regularly and updated according to changes in populations, needs and technologies.

2.6 FUZZY LOGIC FOR DECISION-MAKING

Decision-making can become a very complex process when several parameters need to be considered and weighed. Moreover, in municipal waste management, decision-making involves multiple objectives, which are intricately intertwined within political issues, and require a consensus between values, goals and stakeholders. It can become even more complicated when qualitative aspects are involved alongside quantitative

data. Environmental decision-making often requires some form of compromise between conflicting values of interest. Therefore, a successful management strategy needs to be developed with adapted and appropriate assessment procedures and weighing of various aspects involved. Silvert (1997) applied fuzzy logic to derive fuzzy indices of environmental conditions and to classify ecological impacts. This provided simple scoring procedures for classifying and ranking ecological impacts. Silvert further claims that fuzzy logic can be applied in a way that can resolve several environmental problems, which include incompatible observations and implicit value judgment. It can link, compare and associate a wide range of information such as objective quantitative data, qualitative information, opinions, social needs, and translate this information into specific environmental impacts and consequences; it can assign different weights to different types of observations and can deal with missing data, offering a more global picture rather than a limited concept [Silvert, 1999]. Weighting can be done by calculating the weight of the attribute based on the number of attributes [Hämäläinen, 2003]. This supposes that a thorough study has already been conducted and therefore allows a review of all attributes involved in the decision-making process. In a Task Force Decision-Making Process [Fernald Citizen 1994], pros and cons of alternatives and options were constantly weighed and ultimately, no one criterion ranked more importantly than another did. This was possible by reaching a complete understanding of the opportunities, constraints, risks, costs and benefits associated with alternative approaches. Aravossis et al (1999) used an indirect weight assignment by distributing a well-prepared questionnaire to decision-makers involved in the process, to achieve a classification of the evaluation criteria by priority. His objective was to minimize subjectivity by giving more weight to those groups that have more influence. Notwithstanding, who is to say that a mayor's opinion has more weight than that of its constituents? Without the budget, there cannot be a project. Without community approval, there also cannot be a project. This approach is therefore very controversial.

The selection of appropriate indicators is crucial in a decision-making tool. Van de Klundert (2000) proposes the following:

- **Relevance** with regard to Agenda 21 and the concept of sustainable development
- **Validity:** really related to what they are supposed to indicate or measure
- **Reliability:** indicators should convincingly demonstrate that objectives are being met
- **Easy to understand**: clear in content, even for people that are not experts on the issue
- Providing a **clear overview**
- **Sensitivity** over time and to change in the situation being observed
- **Availability** of data and time sequences
- **Ability** to acquire data
- International **compatibility**
- **Adaptable** to the context of developing countries

Nevertheless, the fuzzy logic approaches to environmental and ecological issues is not readily accepted as the solution for decision-making [Tran et al, 2002]. In fact, Silvert (1997) agrees that managers and decision-makers may not be eager to accept and incorporate fuzzy logic approaches in their decision-making process. The main problem foreseen in non-objective approaches is the efficiency of weighting the various aspects that need to be evaluated. Yet, these weights have a direct impact on the outcome of the decision in proportion to their importance.

2.7 REVIEW OF SOME EXISTING WASTE MANAGEMENT MODELS AND TOOLS

Several computer models and decision-making tools have been developed over the years, each one offering a different approach to a similar problem. The degree of certainty of each model is generally based on the precision of the input data and on the level of assumption allowed by the model. For example, the quantity of waste produced in a municipality can be entered based on the number of tonnes of waste that enters into a transfer station daily; this gives the exact quantity of waste that will undergo some form of treatment. The quantity of waste can also be estimated based on the number of inhabitants in a municipality on the assumption that each person generates a specific amount of waste, for example, 0.5 kg per day of waste. This assumption clearly cannot allow precise calculations but rather an estimate of what is the daily waste production. Bakkes et al (2000) reviewed a number of global models for scenario studies on environmentally sustainable development. These models are not specifically designed for MSW management but involve decision-making in relation to their impacts on the environment. Assessments of horizontal integration, that is the integration between different aspects of a model's domain, and vertical integration, the degree to which a model covers the complete cycle of human induced change, from driving forces, to pressures, to changes in state to impacts and finally to response is included. The selected models were divided into six groups.

Group 1

Models of the first group have been designed to provide an integrated insight into a range of environmental, economic, and socio-cultural aspects of sustainability.

WORLD 3: This model was the first comprehensive integrated global simulation model. This system dynamics model covers a wide range of population, food, energy, environmental and economic issues. It offers horizontal integration with limited vertical integration. The major drawback of this model is said to be the fact that it only provides scenarios on a global level, with no regional desegregation. It is difficult to use because it required thorough knowledge of programme coding.

International Futures (IF): This is a global system dynamics model based on a technology similar to that of WORLD 3. It is capable of simulating economic development from the year 2002 up to the year 2050 at both global and regional levels. Although horizontal integration is increased, vertical integration suffers from problems similar to WORLD 3. Consequently, the model is incapable of deriving concrete underpinning for policy analysis.

TARGETS: This programme serves as a Tool to Assess Regional and Global Environmental and Health Targets for Sustainability (TARGETS). It is a global system dynamics model, which estimates the impacts on ecosystems and humans.

THRESHOLD: This system dynamics model covers the domains of the three previously mentioned models. It combines social, economic and environmental domains in an extremely transparent model. Market and government behavior play key roles in the structure of the model, making it possible to make political adjustments and strategies as to view their impacts. Generally adjusted for national level usage, the model has been used in a number of developing countries, as well as in Italy and in USA. There is an impressive level of details in output variables, which, however, are not applied in the description of the cause-effect chains. Horizontal integration is very elaborate while vertical integration is implemented in fewer details.

POLESTART: This is an integrated accounting framework developed by SEI Boston Center. It is an extensive data set containing a wide range of social, economic and environmental variables, which includes political and cultural variables. The Polestart model calculates the consequences for the environment and world resources availability based on standard parameters and can be used at very global or very local levels. Nevertheless, it has very low level horizontal and vertical integration, which limits the possibility for integrated and balanced answers required in decision-making.

Group 2

The second group of models is focusing on linkage between energy and the environment. As such, these concentrate on emissions, climate change, acid rain, and in depletion of natural resources.

Atmospheric Stabilization Framework (ASF)
This is an accounting framework covering the fields of energy, agriculture, deforestation, GHG emissions and atmospheric model. It consists of four sectors: residential, commercial, industrial and transport. An agriculture model is linked to a deforestation model, which interactively calculates the agriculture production, and the area of deforestation based on population and GNP development.

Multiregional Approach for Resource and Industry Allocation (MARIA): This is an inter-temporal and non-linear optimization model focusing on the assessment of technology and policy options available to address global warming. The model is based on the DICE model and covers aspects of economics, land use, natural resources and energy, for which its analysis for emissions is limited to global carbon emissions.

It offers limited horizontal integration because of its narrow focus, and limited vertical integration due to the exogeneity of key economic indicators. It lacks details in policy relevance.

Model for Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE): Is a dynamic linear programming model, a sub model of the IIASA integrated modeling framework. It is used in tandem with the MACRO macro-economic model (top-down) with MESSAGE (bottom-up) modeling techniques. It

calculates energy demand, supply and emission patterns based on economic input. The model requires exogenous input of population and GNP scenarios on a regional level thus deriving scenarios for future energy demand. The model divides the world into eleven regions. It lacks both vertical and horizontal integration.

Mini-Climate Assessment Model (MiniCAM): This model has low levels of both vertical and horizontal integration, and the economic and environmental issues addressed are very limited. There is a complete lack of socio-cultural aspects and no feedback mechanisms other that the final link of output to input.

Group 3

The third group is a special category since the models started as energy-environment models but evolved as global change models.

Asian Pacific Integrated Model (AIM): It is a general equilibrium model developed by the National Institute of Environmental Studies in Japan, which focuses on the assessment of greenhouse gas emissions. It calculates the level and type of energy use based on external socio-economic scenarios and requires the exogenous input of GDP, population, resource base and lifestyle developments. Land use is calculated with the Land Equilibrium Model based on biomass energy demand, food consumption patterns and technological change. GHG emissions are calculated and in turn fed into AIM Climate Model, and subsequently the AIM Impact Model. Outputs can then provide feedback concerning socio-economic scenarios. AIM is limited in horizontal integration because of the narrow focus and in other aspects of environmental sustainability. Exogenous treatment of socio-economic developments further limits vertical integration.

Integrated Model to Assess the Greenhouse Effect (IMAGE): This model was originally developed by RIVM to assess the impact of anthropocentric climate change. IMAGE 2.2 divides the world into nineteen regions (including Antarctica and Greenland). It is an integrated model that consists of three sub-models: Emissions from the energy sector are modeled with the TIMER simulation model, a system dynamics model for energy related information in 5 sectors of the economy and the Terrestrial Environment System (TES), which simulates land-use and land-cover change, and their consequences for biophysical processes. Atmospheric-Ocean System (AOS) calculates the behavior of greenhouse gases in the atmosphere and its effects on temperature and precipitation patterns. Exogenous inputs into the model include economic data, technological change, demographic development and control policies. Other models associated but not integrated into IMAGE include CPB's Worldscan (macroeconomic projections, PHOENIX demography and population health, and EDGAR, historical emissions and related statistics on grid basis.

There is a lack of horizontal integration in IMAGE from the perspective of general sustainability analysis, although exemplary within its narrow focus, introduced at all computing levels. Vertical integration is more limited with a lack of feedback from the outcome of the model and the input.

Group 4

The fourth group focuses on links between economy and the environment. These models support sophisticated and detailed scenarios of economic development and translate these into rough sketches of possible environmental impacts

JOBS: It is a global model that divides the world into ten regions, and solves a sequence of static economic equilibrium. The model uses the GTAP database as a source. Horizontal integration is limited to a selected few economical and economic indicators. Vertical integration is also limited by the non-dynamic modeling technique. Furthermore, a major drawback is its lack of accessibility.

GTAP: Is an extensive economic database as well as a general equilibrium model of the world economy. It is considered as a sophisticated tool for the simulation of global economic and trade patterns, but does not address environmental and socio-cultural aspects. The model exhibits a strong degree of vertical integration with horizontal integration limited to the trade sector.

WorldScan: This model is based on neo-classical economic theory with a primary emphasis on economics. It is suitable for a wide range of applications in the fields of energy, transport, trade and environmental policy. It has been used with IMAGE for developing climate scenarios and can be used to analyze policy strategies for the implementation of the Kyoto protocol on climate change. The model divides the world into twelve regions, the economy into 11 sectors including differing factor requirements. The model is lacking horizontal integration with environmental, institutional and socio-cultural factors, while vertical integration is insufficient due to a lack of feedback mechanism.

WORLD Model: This model is based on the familiar static input/output model, already extended by the explicit representation of investment and international exchange. This model has evolved over time into a dynamic form and divides the worlds into sixteen geographic regions, each described into approximately fifty interactive sectors. Environmental aspects have been added and outputs in agriculture products, minerals and emissions of pollutants are measured in physical units.

FARM: This model was developed to evaluate the effect of various global change phenomena on long-term agricultural and environmental sustainability. The modeling system links a GIS component. The model divides the world into 12 production regions.

Bakkes et Al (2000) conclude that as of the year 2000, there was no “ideal” global model for the development of scenarios of environmentally sustainable development. In order to efficiently explore various scenarios, models need to have regional specificity, demographic components, institutional components and environmental specificity.

EPAIDEA model [Ruesch, 2000] is a spreadsheet base Cost Estimating Model that is used for Illegal Dumping Economic Assessment (IDEA). It is designed to be intuitive using excel and prompting the reader with questions, making the spreadsheet user-friendly. Its objective is strictly to assess the costs associated with illegal dumping.

USEPA (1997) also developed a Handbook "**Full Cost Accounting for Municipal Solid Waste Management: A Handbook"** to help implement full cost accounting in local communities. This handbook aims at introducing key FCA terms and concepts to understand the costs associated with MSW management at community level, building on local government experience.

CABAM [Lee, 1997] is a fiscal unit-based analysis tool that was developed in response to the needs and benefits of early financial assessment. It is a MS Excel based design tool and allows economic assessment at the conceptual design stage. It has been used in financial reviews but not in the context of waste management.

With the increasing requirement of environmental impacts for various products, the Swedish Environmental Research Institute Ltd (IVL, 2000) in conjunction with IVL, the Swedish Institute of Production Engineering Research IVF, the Centre for Environmental Assessment of Product and Material System (CPM), and The Swedish Institute for Food and Biotechnology (SIK) conducted a study to review existing LCA software tools available. Numerous software programmes are available and IVL surveyed 24 software tools from 22 suppliers, based on questionnaires answered by suppliers.

Results show that most software come from Europe and range from free to 20,000 USD. 19 software programmes are intended for LCA experts, 15 for design engineers, 18 for environmental engineers and 9 for all types of users.

Main LCA software programmes can be summarized as follows:

1. **Balance 3.0 (Institute of Energy Economics and the Rational Use of Energy (IER), University of Stuttgart)** is mainly designed for accounting LCAs and it is intended for LCA experts, design and environmental engineers. The database includes data covering materials, transport, waste disposal, electricity and heat supply, etc, direct and total energy consumption and environmental interventions of production sectors. New data can be documented by the user.

2. **The Boustead Model version 4.2 (Boustead Consulting Ltd)** is mainly designed for function-based and accounting LCAs and it is intended for LCA experts, design and environmental engineers. The database contains data covering fuel production industries, material (iron, steel, a number of non-ferrous metals), glass, thermoplastics/polymers and intermediates, construction materials, acids and bases, packaging materials, retailing and transport. Emissions are distinguished between where the various emissions occur, e.g. fuel production, transport operations or process operations. New data can be added by the user and can be documented by name, operation, units, year, company, etc.

3. **Cambridge Engineering Selector - Eco-selector (Granta Design Ltd)** is mainly designed for material selection to minimize environmental impact. The software is consequently not an LCA product and does not perform LCA calculations. It is intended for design engineers, environmental engineers and materials specialists. The database contains data on material properties. New data can be added and documented by the user. Documentation of the LCA (metadata) is possible.

4. **CUMPAN 1.44 (debis Systemhaus Industry GmbH)** is designed for screening and full LCAs. It is intended for LCA experts, design and environmental engineers, and for LCA beginners. The CUMPAN database contains data concerning metals, plastics, energy, fuels and proprietary, and has the size of about 250 datasets. New data can be added by the practitioner.

5. **ECO-it 1.0 (Pré Consultants BV)** is designed for screening LCAs. It is suitable for LCA experts or anyone who wants to make a quick product screening. The database includes input and output data covering material production and processing, energy generation, transport, waste treatments, waste scenarios. It is possible to add new data.

6. **EcoLab version 5.1.2 (Nordic Port AB)** is designed for function-based and accounting LCAs. It is intended for LCA experts as well as for environmental engineers. The database contains 271 activities (SPINE models of industrial processes). They cover production of metals, plastics, wood, cardboard, paper, glass, cement, chemicals, electricity and more. There are activities describing molding, rolling, drilling, welding and other processing of metals. Other activities describe combustion of different fuels and waste treatment like scrap recovery, incineration and landfill. New data can be added by the user, who also can change everything.

7. **EcoScan 3.0 (TNO Industrial Technology)** is designed for screening LCAs and intended for engineers. The software has a data format based on SPOLD. The database NOH Eco-indicator .95 is included in the software and it includes data covering materials, processes, usage, transportation, end of life, packaging, disposal and semi-manufactures. EcoScan 3.0 is also compatible with EcoScan .97 database, IdeMat .96, and forthcoming IdeMat 2000. In addition, you can make your own database with references to the origin of data.

8. **EDIP PC-tool version 2.11 beta (Danish Environmental Protection Agency)** is designed for function-based and accounting LCAs. It is intended for LCA experts and design engineers. Data included in the software is not specified for a certain branch of business, but the current version of the database primarily supports electromechanical processes. The database contains unit processes such as materials, energy systems, transport systems, products, sub-assemblies, disposal processes, production processes, substances and auxiliary materials. New data can be added and documented by the practitioner.

9. **EPS 4.0 Design System (Assess Ecostrategy Scandinavia AB)** is designed for screening accounting LCAs. The impact assessment is emphasized, and the valuation method EPS, Environmental Priority Strategies, is included in the software. The software is intended for LCA experts, design engineers, environmental engineers, purchase organizations, sales, and management in corporations. The data included in the software is not specified for a certain branch of business. The database, SPINE, included in the software contains data concerning materials, processes, transports and products. New data can be added and documented by the practitioner.

10. **GaBi3 (PE Product Engineering GmbH)** is designed for function-based LCAs and it is intended for LCA experts and similar persons. The software has

extension databases, which are paid separately and can be used only in connection with the professional database. They include intermediates organic, intermediates inorganic, energy (power stations, country specific data, dynamic power plant model), steel (sheets, alloyed steel, alloying elements), aluminum (profiles, sheets, castings, alloying elements), non-ferrous metals (primary), plastics (high performance plastics, compounds), coatings (painting processes, paint, solvents, pigments fillers), end of life (disposal, recycling, dynamic process models), manufacturing (single processes, material specific processes, dynamic processes). The practitioner can add new data.

11. **GEMIS (Öko-Institut (Institute for applied ecology))** is designed for screening and accounting LCAs. It is intended for LCA experts, environmental engineers, and analysts in utilities, institutes, SMEs (small and medium enterprises). Only physical valuation methods (CO2-equivalents, etc) and external costs can be used. The database includes data on approximately 500 products and 4000 processes in more than 20 countries. Industrial sectors, which companies using the software are involved in, are utilities (gas, electric), district heat, oil, building, agriculture, chemicals and transport. New data can be added and documented by the practitioner. Documentation of the LCA (metadata) is possible.

12. **JEMAI-LCA (JEMAI, Japan Environmental Management Association for Industry)** is designed for function-based LCAs. It is intended for LCA experts and design engineers. It is only available in Japanese. The data covers mainly processes (gathering resources, energy, manufacturing, transportation, use, disposal, etc.) The practitioner can add new data.

13. **KCL Eco 3.01 (KCL, Finnish Pulp and Paper Research Institute)** is designed for all types of LCAs, i.e. function-based, screening and accounting LCAs. It is suited for all types of users, e.g. LCA experts, environmental and design engineers. The software has the data format Data Master (based on SPOLD) and is compatible with the EcoData database. The EcoData database involves data for pulp, paper and board production processes, chemicals, energy, transports, wood harvesting, de-inking processes, and waste management. The practitioner can also add new data by himself, together with a note regarding the source.

14. **LCA Support version 2 (NEC Support Kansai Ltd, NEC Corporation)** is designed mainly for screening and accounting LCAs. It is suited for all types of users, e.g. LCA experts, environmental and design engineers. The software only communicates in Japanese. LCA Support version 2 is compatible with three databases: LCA database series Japan, which contains general data covering material and energy production in Japan, LCA database series 1995 Input Output table, which contains about 4,000 data concerning production of overall Japanese sectors based on l/O tables, and LCA database series BUWAL, which mainly contains packaging data in Europe. In addition, you can add new data with references to the sources.

15. **LCAIT 4 (Chalmers Industriteknik, Ekologik)** is not designed for any specific user, which means that LCA experts, design engineers, environmental engineers, LCA beginners and others can depending on LCA support, software user support and available data use the programme. LCA-it 4 is appropriate for any type of LCA work (function-based LCA, screening LCA, accounting LCA and other).

The data included in the software is not specified for a certain branch of business. The software includes a basic software package with energy data and transport data, which includes production and combustion of fuels, production of electricity and different transport modes. Additional data modules are to be purchased separately. New data can be added and documented by the practitioner.

16. **PEMS v4.6 (Pira International)** is designed for function-based, screening and accounting LCAs. It is intended for LCA experts. The database, which is transparent, includes data covering energy consumption, waste management, transport and materials. It is possible to add new data.

17. **REGIS 2.1 (Sinum AG . EcoPerformance Systems)** is designed for screening and accounting LCAs. The tool can also be used in corporate eco-balances (ISO 14031). The software is intended for LCA experts, environmental engineers, technical staff and environmental managers. The data included in the software is not specified for a certain branch of business. The database includes data covering energy systems, disposal systems, transportation, packaging materials, materials related to the printing industry and various auxiliary materials. New data can be added and documented by the practitioner. Documentation of the LCA (metadata) is not possible in the software. The user can, however, add comments.

18. **Sima Pro 4.0 Light with Scripts (Pré Consultants BV)** is a function based LCA, screening and accounting LCAs, and for cradle to gate, end-of- life studies and other partial LCA studies. The applicability for certain LCA work depends on the scripts and databases made to work with the software. The software is intended for design engineers, environmental engineers and for non-LCA experts that wish to use LCA with predefined scripts. Input/output data cover material production and processing, energy generation, transport, waste treatments and waste scenarios. New data can be added in projects only but cannot be used in the scripts themselves.

19. **Sima Pro 4.0 single user/multi user commercial (Pré Consultants BV)** is suitable for function-based LCA, screening and accounting LCAs, and for cradle to grave, end of life studies and other partial LCA. The tool is intended for LCA experts, design engineer and environmental engineer. The database includes input and output data concerning material production and processing, energy generation, transport, waste treatments and waste scenarios. It is possible to add new data in projects or to the database.

20. **SIMBOX Version 2.6 (EAWAG)** is not specifically an LCA software, but a simulation tool for material and energy household analysis. Intended users are environmental engineers, university people, and staff at governmental offices or other companies. The calculations are based on serious and numerically accurate mathematical procedures as are used in real simulation programmes. Mathematical formulas, sensitivity analyses, and other important simulation techniques are available.

21. **SPINE@CPM Data Tool 3.0 (CPM) is designed for function-based LCAs,** screening and accounting LCAs. The software is intended for LCA experts and

environmental engineers. The software does not include any database. New data can be added and documented by the practitioner. Documentation of the LCA (metadata) is possible. SPINE@CPM Data Tool communicates with SPINE databases, which are based on Microsoft Access and the SPINE LCI data format. SPINE databases may be built up by anyone, using SPINE@CPM Data Tool.

22. **PriceWaterhouseCoopers)** can be used for all types of LCA work and is intended for LCA experts and environmental engineers. Major types of database include data covering pulp and paper, plastics and chemicals, glass, steel, non-ferrous metals, energy, transport and end of life. New data can be added by the practitioner and information about data is stored in independent modules attached to the data set.

23. **Umberto 3.5 (IFU Institut für Umweltinformatik, Hamburg GmbH)** is designed for function-based and accounting LCAs. It can also be used for environmental business assessment in general, process planning and optimization, economical and ecological improvement of processes, products and sites. There are branch solutions of Umberto provided by industrial associations available. The software is intended for all types of users. The software contains data of material hierarchies, organized as material groups with technical, economic and ecological material properties, process-data, e.g. transportation processes with parameters for several truck types, distances, etc. New data can be added by the practitioner.

24. **WISARD version 3.7 (ECOBILAN)** can be used for function-based and accounting LCAs. The software is intended for LCA experts, environmental engineers and technical staff from local authorities and waste managers. The database contains data of processes (waste management) and ancillary materials/processes (e.g. lime production, diesel production). New data can be added by the practitioner.

Group 5

Software specialized for solid waste

WastePlan Software for Integrated Solid Waste Planning Version 5.0 is a micro-computer-based modeling tool for use in integrated solid waste planning. It was developed by Tellus Institute in 1988 for the U.S. Office of Technology Assessment, which used the model for analyses presented in Facing America's Trash, and has been continually enhanced and updated to meet the needs of dozens of public agencies and researchers in the field of solid waste management. WastePlan is generally used for integrated solid waste management planning; data organization and management; full cost accounting; least cost system planning; capacity analysis/system mass balance assessment; and sensitivity/scenario analysis.

POLESTAR System version 2000 was developed by STOCKHOLM ENVIRONMENT INSTITUTE's (S.E.I.), International Institute for Environmental Technology and Management. PoleStar is an adaptable accounting and model-building framework designed to assist the analyst engaged in sustainability studies—not a rigid

model reflecting one particular approach to environment and development interactions. It addresses critical aspects of the transition to sustainability, scenario analysis capacity building and policy studies. The software includes a Solid Waste Module that allows the building of an analysis of the solid waste system. Relationships built into the Basic Structure cover waste generated and processed, landfill area and methane emissions, waste-to-energy conversion, and emissions from incineration.

SWPlan handles the entire municipal solid waste flow from waste generation to final disposal including waste Reduction, Recycling (19 commodities), Yard Waste Composting, Waste-to-Energy (WTE) Incineration, Refuse-Derived-Fuel (RDF), MSW Composting, Ash Disposal and Landfills with/without Transfer Stations. SW Plan calculates the quantity of waste, and the type of waste. The software determines capital and operating costs, debit service, and transportation costs, and considers revenues from the production of RDF, and from the sale of recyclables, electricity and steam.

GIGO A Spreadsheet Programme for Integrated Municipal Solid Waste Management was developed by the Department of Civil and Environmental Engineering, University of California in 1993.

Integrated Waste Management System (IWS) and SKIP2 are two waste management software packages developed by P&L Software Systems Limited of the UK. The software is said to have been supplied to many sites across Europe and other countries around the world.

Group 6

Other related software programmes

TEAM (Tool for Environmental Analysis and Management) is Ecobilan's powerful and flexible Life Cycle Assessment software used as a tool to: Compile life cycle inventories using Ecobilan data, own data, or any combination thereof; perform sensitivity analyses in an automated fashion to identify 'data hot spots'; investigate 'what if' scenarios via user friendly 'Control Panels'; conduct life cycle impact assessment determinations using any one of the protocols incorporated within the software; report findings in a variety of different ways making use of the tabular / graphical display options.

DEAM™- Data for Environmental Analysis and Management Millennium kit encompasses 51 of the Ecobilan's environmental database most used modules, which are to be used by TEAM.

SPSS (Statistical Package for the Social Sciences) is a data management and analysis product that can perform a variety of data analysis and presentation functions, including statistical analyses and graphical presentation of data. Among its features are modules for statistical data analysis, including descriptive statistics such as plots, frequencies, charts, and lists, as well as sophisticated inferential and multivariate statistical procedures like analysis of variance (ANOVA), factor analysis, cluster analysis, and categorical data analysis. SPSS is particularly well-suited to survey research, though by no means is it limited to just this topic of exploration.

Dolphin Software, Inc. is a leader in products and services for Total Chemical Management. Applications are for integrated Material Safety Data Sheet (MSDS) automation, environmental reporting, inventory management, and hazard communication into a cohesive solution tailored to specific data requirements, from the simplest to the most complex chemical management needs,

The **Material Inventory Report System** (MIRS(TM)), first developed in 1988 by A.V. Systems, Inc., is said to be a comprehensive, integrated, flexible and easy-to-use software package for environmental, health & safety compliance and management. MIRS(TM) enables companies to maintain an accurate hazardous materials database and generate EPA approved reports promptly, accurately, and cost effectively.

Logical Data Solutions, Inc. (LDS) is a software that specializes in environmental compliance data management software through the EPOCH product line. LDS provides a full range of services including software products, customized application development, pre and post implementation support, data conversion, application interfaces, and training. EPOCH provides detailed data analysis and reporting capabilities in areas such as; hazardous material management, emissions source management, toxic chemical releases and task management.

DataPipe, is used in electronic efficiency for data collection, risk management and compliance reporting. Developed by Knorr Associates Inc., it focuses on occupational health, safety and environmental fields.

Compliance Suite is used for OSHA/EPA recordkeeping and reporting requirements. Developed by RMS Systems, Inc., it allows the download of existing database into Compliance Suite to avoid lost time and data entry errors. All seven programs, Safety, Training, Audit, MSDS, Right-to-Know, Waste, and Industrial Hygiene share a common database so there is no need to re-enter data.

Chemical Safety Software develops, integrates and supports industry-leading technology for environmental management, addressing all aspects of compliance, safety and chemical management. The focus is on environmental compliance, reporting and management.

ImageWave® provides EHS and MSDS software, MSDS Management, Environmental Reporting, MSDS Authoring Software, Chemical Inventory Tracking, MSDS Databases, Container Labeling, Online MSDS Hosting Services, and more.

SOLUTIONS Software Corporation was founded in 1992 and provides reference data covering: Government Laws & Regulations, Chemical References, Testing & Environmental References, Computer-Based Training, and Miscellaneous topics.

ESP (Environmental Software Providers) delivers integrated environmental, safety, and health information management systems. Environmental, safety, and asset management challenges, ops Environmental and eco-Asset Manager were developed in collaboration with industry partners as practical, robust solutions to everyday environmental and safety challenges.

FacTS is a comprehensive EH&S compliance reporting system with over 30 modules, developed by Quantum Compliance Systems, Inc.,

EnviroWare was designed to track the generation, storage, transportation and disposal of hazardous wastes from a single facility or at a corporate level. It was developed by Contemporary Technologies, Inc.

As seen above, most programmes have been developed for broad uses and therefore few have been elaborated to cater for specific needs associated with municipal waste management. Moreover, although some of the programmes can be adapted or can include environmental issues and waste management, their main objective is for accounting LCAs and their target users are LCA experts and engineers. The five specialized solid waste software are quite interesting and offer a lot of information. However, their usability is complex and requires the user to be experts. Because those responsible for decision-making on MSW management are generally public administrators, it is necessary to have a system that is readily usable and that can offer adaptability for each municipality or location. The easiest approach is therefore for a programme to use a series of questions that can be answered by an administrator who has the answers or that can get the required information through the municipality's specialized personnel, and allow the computer to analyze results from gathered information. One approach is to use an Excel base programme that is readily known and used by most administrators around the world, and that can perform data analysis based on the information gathered through an especially designed questionnaire.

2.8 SECTION SUMMARY

Specific institutions and organizations were created in answer to the problems associated with MSW management in various Asian countries, in order to deal with the increasing amount of waste generated daily. Nevertheless, MSWM remains the responsibility of local governments as to ensure public health to its local population. Moreover, Asian tropical climates and the fast changing waste characteristics make waste treatment and disposal a continuous challenge to decision-makers.

The importance of the role of local communities in decision-making cannot be emphasized enough. In fact, three main stakeholders play a key-role in decision-making. These are the state (central and/or local), the private sector and the civil society. Social constraints such as the high number of waste-pickers are one of the aspects, which must be dealt with. In Asia, tens of thousands of waste-pickers depend on this waste for their daily survival.

Environmental protection and sanitation is everybody's responsibility. Community members, therefore, must actively participate in the protection of the environment and in the prevention of its deterioration. Appropriate monitoring and evaluation schemes need to be developed as to ensure that laws and regulations are implemented and enforced.

Collection of waste, its transformation and final disposal must take into consideration social and environmental aspects. Decision-making involves changes and people generally do not like change. Literature shows that there is a direct correlation between the level of income and the quantity and type of waste generated. This tendency, however, reverses with higher income generated, lowering the quantity and certainly changing the type of waste generated. Valorization of waste should also be considered in

any waste plan. This includes valorization through the sale of recycled materials, through the sale of compost, or through the sale of energy in the form of by-products, which include char, oil, gas, heat, steam or electricity.

Another challenge faced by Asian countries is the shortage of space, thus making siting of a landfill site increasingly difficult. City centers have very dense populations and therefore waste treatment plants need to be located far away from the waste generation source, thus increasing the overall costs of MSWM. The condition of waste to be treated also changes radically depending on the season: the rainy season brings about floods and therefore extremely wet waste, while during the drought season, waste is dry and could sometimes even become flammable. Several techniques in waste management should be used through an integrated system.

The use of fuzzy logic may be one way of identifying an appropriate system. However, key factors such as relevance, validity, reliability, easy understanding, sensitivity, availability, ability, compatibility and adaptability must be taken into consideration when making a decision. These must include the political, institutional, social, financial, economic and technical aspects of MSWM.

Taking the above into account, several decision-making tools were developed for various applications. However, majority of them do not necessarily take into consideration public participation, and are not user friendly. They require specific training on the designed programme, for which decision-makers generally do not have time or appropriate knowledge. Thus the interest to develop a spreadsheet base programme, using Excel, which is a well know programme that is used by most administrator.

3. Identifying key issues

From the beginnings of humankind, waste has been a result of daily life activities. However, with the increasing world population, what was once a controllable issue has become problematic because of the rapidly increasing volume of waste and the fast changes in waste characteristics. Along with technology comes a new type of challenge associated with various types of packaging and products. These need to be addressed in an environmental manner. Moreover, the decreasing amount of land available is proportional to the increase in population. Therefore, landfill is no longer the best and most feasible method for disposal, especially in Asian countries where the population per square meter is very high.

3.1 UNDERSTANDING LOCAL NEEDS

Each country and each community has its specific needs and requirements, along with constraints and expectations. Therefore, several conditions determine the choice of an appropriate MSWM and more specifically, the technology to be used for waste disposal. A baseline review of accumulated data is most efficient in identifying specific needs and requirements of a community. The following information is of essence to clearly understand the local conditions.

3.1.1 LOCAL DEVELOPMENT

The level of economic development is directly proportional to the quantity and quality of waste generated, although it varies according to country and culture. The following chart shows the correlation between the gross national income and the quantity of waste generated per capita per day.

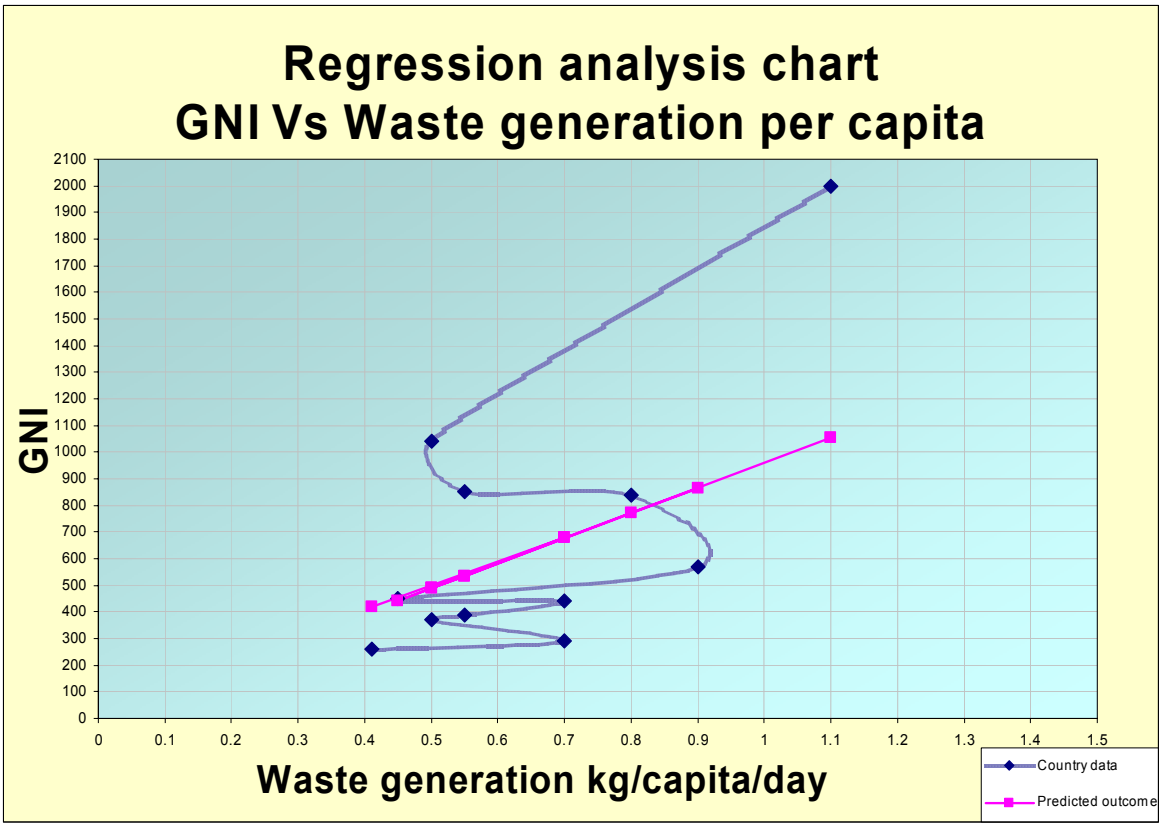
Table 8 Correlation between Gross National Income (GNI) and waste generation in selected countries

Country	GNI World bank 2000	Waste generation [kg/capita/day]	Reference
Nepal	240	0.20 - 0.50	(UNEP, 2001)
Cambodia	260	0.33 – 0.49	(Yem, 2001, JICA 1999. WHO 2004))
Lao PDR	290	0.70	(Hoornweg, 1999)
Bangladesh	370	0.50	(Hoornweg, 1999)
Vietnam	390	0.55	(Hoornweg, 1999)
Pakistan	440	0.60 - 0.80	(World Wildlife Fund, 2001)
India	450	0.30 - 0.60	(Ahmed, 2000; Akolkar, 2001)
Indonesia	570	0.80 - 1.00	(Mukawi, 2001)
China	840	0.80	(Hoornweg, 1999)
Sri Lanka	850	0.20 - 0.90	(Jayatilake, 2001; Hoornweg, 1999)
Philippines	1040	0.30 - 0.70	(World Bank, 2001)
Thailand	2000	1.10	(Hoornweg, 1999)

Source: Christian Zurbrügg, Department of Water and Sanitation in Developing Countries (SANDEC), Swiss Federal Institute for Environmental Science and Technology (EAWAG), Urban Solid Waste Management in Low-Income Countries of Asia How to Cope with the Garbage Crisis

The above table shows a trend of increase of quantity of waste generated per capita per day directly proportional to the increase of the GNI. Nevertheless, one can see that Cambodia has a very high waste generation that could be attributed to the quantity of organic waste generated, which has a high density and therefore shows a high weight.

Figure 1 Regression analysis chart GNI Vs Waste generation per capita



The regression analysis chart clearly shows steady increase in the expected quantity of waste produced in line with the GNI increase, although at lower GNI, the quantity of waste varies between 0.5 and 1 kg per person per day. This is most likely associated with local habits and culture. However, when GNI reaches 1,000 there is a steady increase in the quantity of waste generated. This is mainly associated with purchasing power and consumer habits, which do not change much over time but do increase with GNI. In countries such as Thailand, for example, foods sold on street sides are wrapped in plastic or styrofoam containers, which accounts for a large part of the waste found in the waste stream. In rural settings, this is different since people cannot always afford plastic and therefore wrap food in newspapers or in natural tree leaves.

GNI levels also have a direct impact on labor costs and local resources, which are associated with personnel, country financial and economic resources. Access to funding for waste management is often difficult for developing countries since most of the available funding is allocated to infrastructure projects. Nevertheless, waste management has a direct impact on local development and therefore should not be left to the

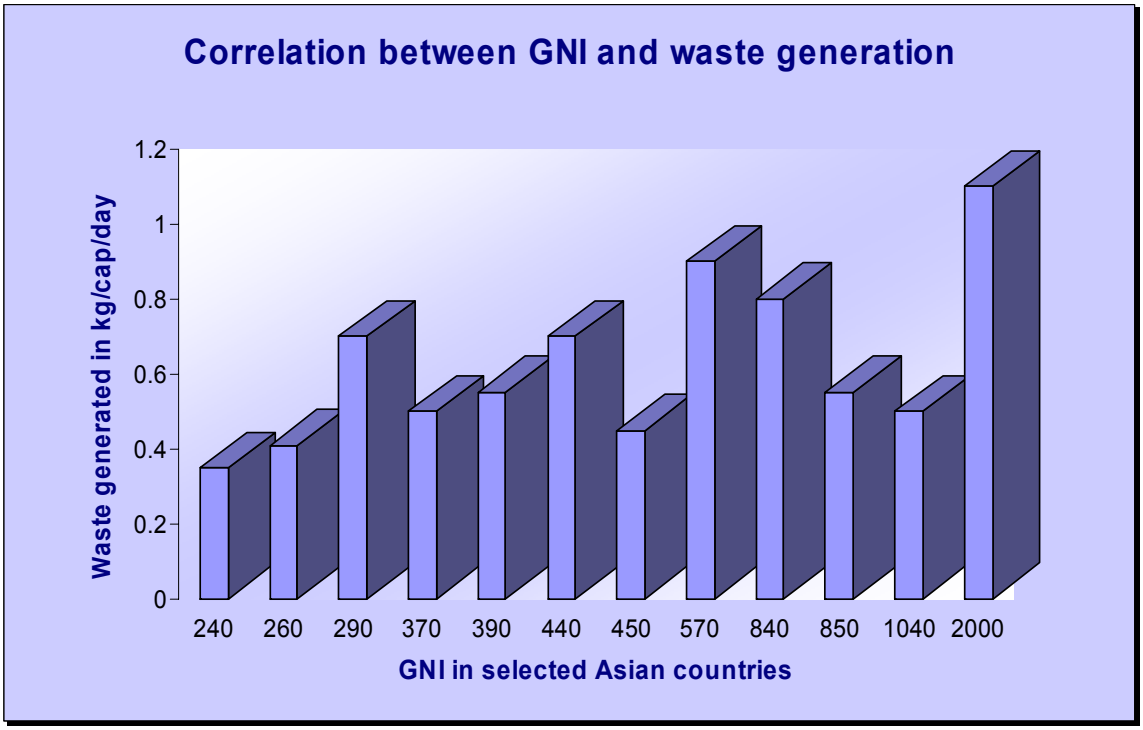
industrialization era of the country but rather should be integrated into urban development programmes.

With low income are the less educated people and a high number of unskilled laborers that are to be involved in the handling of the country's waste. It is therefore imperative that the technological advancement and complexity of the system take into consideration the level of competency of the local working population. In many cases, labor-intensive systems may be more economical at purchase, and less complicated to operate and it could simultaneously generate employment to local labor forces in need of sustainable employment.

Notwithstanding, it should be noted that the tendency of waste increase with GNI is reversed for developed countries mainly because of an increasing awareness of problems associated with waste recycling. Industrialized countries, therefore, have developed waste minimization schemes, which in turn reduce the quantity of waste per capita.

The following figure shows the varying correlation between GNI and waste generation, presenting an overall increase of the quantity of waste generated according to the income. The quantity of waste generated varies from one country to the other according to tradition, cultural and eating habits. However, one can still see the trend of the correlated increase.

Figure 2 Comparative correlational chart



3.1.2 GEOGRAPHICAL ASPECTS

Several geographical aspects need to be considered when identifying a site for a waste treatment plant. These include:

- Siting constraints
- Need for Topographical information
- Climatic conditions
- Existing environmental programmes

3.1.2.1 SITING CONSTRAINTS

Siting for a new project remains one of the most difficult issues to be resolved within the geographical aspects. The identification of an appropriate and suitable site is becoming increasingly difficult the world over. The fact is that communities are becoming more aware of their rights and as such are enforcing these rights and requesting that the treatment plant be located far from their community. This places an important burden on municipalities even for those that are willing to take all precautions to protect the people and the environment. Misinformation is the main cause for the NIMBY (Not In My Back Yard) syndrome; many treatment plants are more environmentally friendly than manufacturing or industrial facilities.

Environmental impact assessments followed by a public hearing are becoming standard requirements in most countries as to ensure social acceptance thus facilitating implementation and separation. This allows a better selection of sites taking into consideration the type of soil, the groundwater table, the nearby populations, and often allows some "*droit de regard*" on the part of the local population. Community participation in these waste management projects is necessary to ensure their success. Finally, a waste treatment plant should not be located too far from the point of collection as to avoid hazards and nuisances such as smell and littering during transport, along with increased costs associated with long distance transportation.

3.1.2.2 TOPOGRAPHICAL INFORMATION

The topography of the potential site needs to take into consideration the altitude, the flows of surface waters, the ground and the underground properties. The soil and subsoil properties need to ensure the stability of the structure and the impermeability of the site as to ensure that no leachate can enter into the ground and migrate into the groundwater. A soil analysis is also advisable as to verify that no previous contamination exists on the site. Clay soil is the most advisable soil structure for the installation of a MSW treatment plant. A waste treatment plant should not be located in proximity of surface waterways or over a groundwater table.

3.1.2.3 CLIMATIC CONDITIONS

Climatic conditions are determinant in the quality of waste thus a major factor in determining the type of treatment most suitable for the waste. These conditions include temperature, humidity, annual rainfall, intensity of rainfall, thermal inversions, wind velocity, and sunshine. This is especially important in hot and humid countries such as Thailand, since the higher the humidity level of the waste, the less appropriate is incineration, unless the waste undergoes a drying pre-treatment.

3.1.2.4 EXISTING ENVIRONMENTAL PROGRAMMES

To ensure the feasibility of the project, it is necessary to verify all existing MSW treatment projects in the vicinity of the proposed new project as to ensure the supply of the minimal quantity of waste to be fed into the MSW treatment plant. In case other projects have already been built or in the pipeline, it becomes necessary to calculate the amount of waste already allocated to these plants for the new project plant. Residual waste produced from existing plants may, in turn, offer a supply of pre-treated waste to a new plant. Such could be the case of an RDF facility that could supply RDF to an incineration plant.

3.1.3 HUMAN DEVELOPMENT

- Demographic growth
- Waste generation increase and changes
- Population density
- Infrastructure development

3.1.3.1 DEMOGRAPHIC GROWTH

Population growth must be taken into consideration when calculating the amount of waste produced within a municipality. This growth is usually assessed along with the data available for the country. Nevertheless, migration to towns and cities is a factor affecting the populations in urban settings. Many rural people, thinking that they can earn a better living for themselves and their family in a large city, leave their family behind and go to work in factories or as taxi drivers in the cities. These people are not officially registered in the city and as such, often are not included in the estimated number of people living in a city since they are registered in their respective villages. Moreover, commuters from nearby municipalities, may be residents of another locality, but are still taking their breakfast, lunch and dinner within the town, hence generating waste.

Another group that needs to be considered is tourists. Although they are not registered and only passing through, they are important generators of waste and must always be considered in a study. The Ministry of Tourism or its equivalent should be in a position to provide data for the number of tourists passing through a certain locality.

3.1.3.2 WASTE GENERATION INCREASE AND CHANGES

As mentioned in the above section, the quantity of waste generated may not only increase or decrease but it can also be seasonal, and changes in the composition and properties of waste can also be associated with the season. The fact is that during the rainy seasons, vegetation is dense and therefore the quantity of fruits and vegetables is abundant. It is thus likely that the quantity of green waste becomes higher during the rainy season compared with the dry season. The more fruits and vegetables along with the quantity of rain further render the waste with a very high humidity level.

Recycling programmes also have a major impact on the quantity and especially the type of waste to be sent for treatment. In many countries around Europe and North America, plastic waste, paper, cardboard and metal items are segregated at household level and are disposed of in especially identified bins along the roads, or are collected by specialized trucks. These programmes, whether implemented or planned, must be taken into consideration since they modify the characteristics and quantity of waste to be treated. One of the major impacts in recycling programmes for plastic, paper and cardboard is the impact on the calorific value of waste. Furthermore, the dimensioning of a treatment plant must be made according to the quantity of waste and its evolution over time. In cases where recycling programmes are increasing, or populations decreasing, treatment plants must be built smaller as large plants become prohibitively expensive to run with below-designed capacity of waste.

3.1.3.3 POPULATION DENSITY

Population density plays an important role in the collection of waste. If too dense, the quantity of waste makes it difficult to handle and requires frequent collection. If not dense enough, the distance between collection points followed by transportation to disposal facilities increases the costs.

3.1.3.4 INFRASTRUCTURE DEVELOPMENT

Infrastructure development also plays an important role in waste collection. Accessibility to remote areas, quality and number of roads allow easy or difficult collection of waste around the country. Very narrow roads often obligate waste collectors to use bicycles, tricycles or carts. Dirt roads and roads in bad conditions with numerous potholes also deter waste collectors to enter these areas. These areas are therefore often neglected and the frequency of collection reduced.

3.1.4 WASTE CHARACTERISTICS

- Volume and density
- Moisture content and combustibility
- Recyclability
- Household hazardous waste

3.1.4.1 VOLUME AND DENSITY

The volume and the density of waste are determining factors in the choice of an appropriate and feasible MSWM disposal system. In general, terms, the larger the volume, the most economical a system can become. Small quantities of waste require simpler low cost systems. Transportation costs may also be lowered by increasing the density of the waste using compression or bailing machines. By reducing the volume of the waste, the load capacity of a waste truck may be increased several folds, depending on the performance of the compacting system.

3.1.4.2 MOISTURE CONTENT AND COMBUSTIBILITY

Moisture content is generally associated with the presence of high quantities of food and green waste. In countries like USA where most households have a food waste disposal unit in their kitchen sinks, the moisture content in the waste collected is lower than in tropical countries where all food waste enters the waste stream, and where consumption of fruits and vegetables is high. Moreover, the hot and humid climate associated with these countries further increases the level of humidity. Therefore, combustion of waste is very difficult and requires specific pre-processing prior to treatment. Organic waste can, however, be removed and used to make compost. If not, the whole waste stream needs to go through a dryer prior to combustion, thus increasing the cost.

3.1.4.3 RECYCLABILITY

Waste recycling is becoming increasingly favorable in waste disposal systems. At source recycling is encouraged in many countries where glass, paper and plastics are placed in different containers. The profitability of recycling has yet to be proven but the environmental benefits of recycling certainly justify the effort.

However, it is necessary to take into consideration these recyclable materials before the selection of a system. The most prominent example is the removal of all paper and plastic prior to sending waste into an incineration process. The removal of high calorific value waste such as plastic will have a serious negative impact on the waste to be incinerated.

3.1.4.4 HOUSEHOLD HAZARDOUS WASTE

Household hazardous waste needs to be handled properly. Special facilities need to be prepared in parallel to any waste treatment system as to ensure that those explosive, corrosive and poisonous substances are handled properly and safely. Hazardous waste needs to be treated separately in a secure and environmentally friendly manner, and sent to a secure industrial landfill for safekeeping, or to a special plant for treatment and final disposal.

3.1.5 SOCIAL IMPACT

The social impact of a municipal waste treatment plant plays a major role in the sustainability of this treatment plant. The various impacts must always be considered while deciding the type of treatment plant, as to verify the implications on the local community. Moreover, modern society will not remain quiet and accept any type of system. Therefore, community participation will be needed as to ensure appropriate implementation and proper waste management for a clean and healthy environment.

3.1.5.1 COMMUNITY PARTICIPATION

Community participation has become an obligatory passage for most countries. This means that the community must be considered as a full participant in the decision from the very beginning of the process. A committee is often elected by the local community, which comprises of prominent and influential figures within the community. The issue here is trust. The people must trust and believe in the information received. Members of this committee therefore attend all meetings discussing the benefits, impacts and financial implications of a waste treatment system within the community. A public hearing is generally organized towards the end of the decision process as to allow all community members, including committee members, local and central government officers along with environmental specialist, to present the findings on the type of waste treatment system proposed, the reasons for its selection, and the benefits for the community. By having a committee of local citizens, the process of this public hearing is generally shorter and chances of acceptance by the local community are drastically increased.

3.1.5.2 CULTURAL PRACTICES

Culture and tradition need to be respected when selecting a waste treatment plant. Its location needs to take into consideration religious and cultural traditions. This is why community participation is so important. The community can ensure that traditions are respected while allowing modern technologies to improve the sanitation of the municipality.

3.1.5.3 HEALTH

A good MSW treatment plant must take into consideration the health of its community members, and those of the animals living within the community. This includes environmental impacts on air, water and soil surrounding the waste treatment plant. The location of the treatment plant must also take into consideration the transportation of the waste for disposal and its impact on smell and associated aerosols, along with the waste that can be dropped or lost during transport. The health of sanitation workers must also be protected. Proper gloves, boots and masks should be worn at all times by garbage collectors and by waste pickers to avoid any contamination.

3.1.5.4 EMPLOYMENT GENERATION

One good method for getting community participation is to generate employment within the waste treatment plant. In most Asian tropical countries, labor is cheap and therefore lower automation and higher labor demand for the operation of a treatment plant will generate employment for local community members. Moreover, in many cities and towns, there may be a large community of slum dwellers and waste pickers. The persons that depend on waste picking for survival cannot be straight-out eliminated. They should be trained and employed for recycling and for the operation and maintenance of the waste treatment plant. This will ensure smooth operation of the plant while supporting the local population. Needless to say that the technical level of a plant needs to be considered since the people working as waste-pickers have little or no education and therefore, are ill equipped to deal with high-tech systems.

3.1.5.5 CONSIDERATIONS FOR THE POOR, WOMEN AND CHILDREN

As mentioned in the previous section, slum dwellers and waste pickers need to be considered. Many of the people living off what they collect from waste sites are women and children. Therefore, the new plant should consider these families when dislodging them from their home on wild landfills or within its immediate surroundings. The livelihood of these people must be considered when selecting, installing and operating a waste treatment plant. Although their political voice may be weak, they are community members, and more than ever, need to be supported and protected during decision-making. Their involvement as former workers in the separation of recyclable materials is one solution. Governments, however, should facilitate for children to be sent to school.

3.1.5.6 RESOURCE RECOVERY AND ITS SOCIAL IMPLICATIONS

Resource recovery is an increasingly attractive solution to waste minimization. Although in many cases, its feasibility remains to be verified, most municipalities now include resource recovery within their municipal plan. This can be a good technique to generate income for community members and to save money for the community by minimizing the quantity of waste to be treated. Resource recovery should, as mentioned earlier, be considered prior to the selection of a treatment system since the efficient recovery of plastic and paper within a waste stream will drastically reduce the calorific value of the waste and may render incineration as a non-feasible option. A long-term plan therefore needs to be established as to the direction of the community towards waste management over the following 10 or 15 years as to avoid systems that are operational for a few years and that then need to be closed because they become unfeasible or too expensive to operate by the community.

3.1.6 POLITICAL IMPLICATIONS

Waste treatment is and always was a politically driven decision. For some, it implies generating income, while for others, it is a money loosing enterprise. In any event, waste treatment is costly and new technologies are always trying to convert waste into money.

However, very few have managed to do so and often the best one can expect is to break even over a certain number of years. Municipalities have the responsibility to ensure sanitation for their citizens but at the same time, because of the politics implied, are very reluctant to charge additional taxes for the treatment of waste and wastewater. A decision-maker therefore needs to select a system that is appropriate to the local community while taking into account the costs and impact on taxes for community members. This means that there must be a careful balance between the enforcement of laws and regulations regarding proper management disposal of waste and the costs involved.

3.1.6.1 WORKABILITY OF LAWS AND REGULATIONS

Laws and regulations should well define the rights and obligations of governments and municipalities in terms of collection, transport and disposal. These should take into consideration the health and well-being of people, protection for the environment, and limited budgets of governments. This means that should the law prescribe a fee payable by the citizens, this law should ensure that the citizens can afford to pay the prescribed fee, and that the money collected is used to pay for expenses associated with waste collection and disposal. Should these fees be insufficient, the law should ensure that the central government covers the difference. Laws and regulations should allow or not allow the privatization of waste collection and/or disposal, and give details on the provisions associated to such contracts, should they be allocated.

3.1.6.2 IMPLEMENTATION AND ENFORCEMENT

Once laws and regulations have been defined, their implementation and enforcement must be ensured. Therefore, specific measures need to be taken regarding discharges to surface and groundwater, air discharges, and for the overall protection of public health. In some countries, and some municipalities, these also include recycling strategies. The laws should specify the standards that need to be observed for all emissions and discharges, be they solid, liquid, or gaseous, and should give guidelines for the construction and operation of waste management facilities. Special permits are generally required for the construction of such waste treatment facilities and therefore these permits can describe specific requirements for the constructors, whether they are private or public entities.

Specific rates for the collection and disposal of waste should be ensured. Power purchasing rates should also be specified within the legislation.

In order to verify that laws and regulations are observed, monitoring strategies must be established. These include the establishment of special teams that physically go to the field, observe the methods used for waste management, and ensure that they comply with the laws and regulations. For this, the teams must gather specific information and data, which is then to be compiled and analyzed. Local governments and agencies, depending on the country, must collaborate with the central government in order to ensure that data is collected properly as to reflect the actual situation. Although the central government passes the laws and regulations, it often mandates provincial, state or local governments to ensure waste management activities and therefore the latter are in a

good position to assist in data collection. Nevertheless, because of the limited budgets of local governments, and the increasing decentralization strategies, local governments are expected to contribute to the financing of waste management through local tax-collection strategies. Therefore, the political implications of such tax-collection become key factors; no governors or mayors want to increase taxes or implement new taxes since it would most likely drive them out of office at the following elections.

Finally, fines and citations should be paid whenever an operator does not comply with the law. For example, if a waste collection truck is overweight, or when a landfill does not comply with environmental security standards set by the government, or when air emissions are above the identified standards, and so on. The people allowed to fine must be well identified, and empowered to enforce the law and collect these fines.

3.1.6.3 POLITICAL WILL

The political will is certainly the driver based on the government's priorities and personal interest. Based on existing laws and regulations, along with responsibilities and obligations, each government will address waste treatment in a different way. It is therefore necessary for the decision-makers to well evaluate the costs and implications (political, environmental, financial…) prior to making a final decision on the size and type of the waste treatment system.

3.1.6.4 PRIVATE SECTOR PARTICIPATION

Private sector participation is often a practical solution to local governments. Depending on the existing laws and regulations, private companies are allowed to collect, manage and dispose of municipal waste for the municipality. This may offer the municipality a reduced initial cash outlay that is sometimes difficult to attain. In certain instances, municipalities may offer free of charge the land on which such treatment may take place. The private company can then invest in all the equipment necessary for the treatment, and be paid a specific fee by the municipality for the management and disposal of the waste. This fee must take into consideration the capabilities of payment of the local community; in certain communities, the fee needs to be extremely low because people have extremely low income. Therefore, the type of treatment selected will be driven by the amount of money to be paid to the operator. All investment or sometimes, partial investment can be organized by the private operator.

Another possibility of private investor strategy is for the private company to operate the plant while for the government. Overall, the most common methods of private sector participation is BOO (Build- Own-Operate) which means the private company builds the waste treatment plant, owns it and operates it; BOT (Build-Operate-Transfer) which means that the private company builds the waste treatment plant, operates it for a certain number of years (can be 10 or 15 or 20 years, or more) and then transfers all of the plant to the government. The government may also contract a private company to operate the plant, which is fully owned by the government.

3.2 TECHNICAL ISSUES

There are several steps involved in proper MSW management. These are:

Waste reduction and minimization	• To arrange for the collection and separation of recyclable materials
Collection	• To gather waste from households, commercial buildings, public places, etc.
Separation	• To transform heterogeneous waste into homogeneous waste – manually or mechanically
Processing	• To prepare the waste for a specific transformation i.e. dewatering for incineration
Transformation	• Changing the state of the waste
Physical transformation	Baling Compacting
Chemical transformation	Incineration Pyrolysis Thermolysis Gasification
Biological transformation	Aerobic composting Anaerobic composting
Transfer and transport	• The use of transfer stations • Transport to processing station or to final disposal site
Disposal	• Landfill • Secured confinement of ultimate waste (i.e. ashes, slag…)
HHW handling	• To manage and dispose of municipal hazardous waste in a specific and secure manner

The selection of the appropriate and sustainable system is not an easy task, especially for government officers who are not necessarily trained engineers or specialized in MSWM. Numerous techniques and disposal technologies have been proven feasible throughout the world. Nevertheless, many installations that are suitable for European climates and conditions may not necessarily be adapted for tropical Asian conditions. Hence, several installations failed for a wide range of reasons including inappropriate operation and maintenance, lack of skilled labor, shortage of funding, inappropriate manufacturing materials for tropical climates, and so on.

Hence, it is necessary to review various existing systems and conditions in order to select the most sustainable, economically acceptable and environmentally sound management system for the municipality or the country.

3.2.2 CHOOSING THE RIGHT SYSTEM

In order to identify the most suitable system, it is necessary to conduct the characterization of the waste, as to know its composition and calorific value. Specific physical location of a system is also necessary as to assess social implications and public acceptance. Population density in most Asian countries and especially in urban areas can make sitting a difficult issue. Moreover, tourism can be responsible for a large quantity of produced waste. Planning by central governments along with availability or accessibility of funds are also determinant as to the type of system to be installed. Finally, environmental compliance is required and this is driven by political will, existing legislation and their reinforcement.

For each of the potential MSWM systems, it is necessary to make a sensitivity analysis in order to decide on the most appropriate system. These can be summarized as follows:

1. Will the system accomplish what it is intended to do?
2. Is the option technically acceptable given the financial situation?
3. Is the local labor skill adequately prepared to operate and maintain the selected system?
4. Is the technology cost-effective?
5. Is the manufacturing material appropriate for the local climate?
6. What are the environmental benefits in relation to costs?
7. Would these benefits increase substantially with a slight increase in costs?
8. Would there be a substantial effect on the environment in case of a slight reduction in costs?
9. Is it culturally acceptable?
10. Is it acceptable to the local community?
11. Is it acceptable to the international community?
12. What would be the effect on society if this option were selected?
13. Is this choice in line with the goals of the community?
14. Of those of the country?

The following table shows treatment systems currently used in selected Asian countries.

Table 9 Disposal Methods for Municipal Solid Waste in Selected ASEAN Countries

Country	Disposal Methods (% by weight)				
	Composting	Open dumping	Landfilling	Incineration	Others
Indonesia	15	60	10	2	13
Malaysia	10	50	30	5	5
Myanmar	5	80	10	-	5
Philippines	10	75	10	-	5
Singapore	-	-	30 *(10 in 2002)	70 *(90 in 2002)	-
Thailand	10 **(0 in 2001)	65 **(67 in 2001)	5 **(32 in 2001)	5 **(1 in 2001)	15 **(0 in 2001)
Vietnam	10	70	-	-	20

Source: 98. UNEP, State of Waste Management in South East Asia, 2002, http://www.unep.or.jp/ietc/publications/spc/State_of_waste_Management/index.asp
**Communication with National Environment Agency officials*
***Draft Annual Report, The State of Pollution, Thailand B. E.2544 (2001), Pollution Control Department 2002*

3.2.3 WASTE REDUCTION AND RECYCLING

WASTE MINIMIZATION

Waste minimization is the first stage that should be targeted in MSW management. Because the quantity of waste is reduced, all costs associated with waste management are also reduced, which means lower costs for the collection, transportation, transformation and final disposal. Packaging plays a crucial role in waste characteristics and consequently management. There is a strong correlation between urban development and increased income, rise in standards of living and increase in the quantity of packaging materials. Moreover, in many developing countries and especially in Asia, space for disposal is difficult to find, especially in urban areas where population is generally very dense. Therefore, landfill must be the ultimate disposal method.

Several factors determine whether a waste reduction or minimization programme can be implemented effectively. These include:

- Government control over packaging, whether local or imported, through the formulation, implementation, and enforcement of laws and regulations
- Presence of recycling facilities
- Accessibility to markets for recycled materials
- Public sensitization towards waste reduction

Waste can be reduced in various steps of the waste generation. This reduction can occur by:

- Reducing waste at source (i.e. reduction of packaging)
- Separating waste for re-use and recycling
- Reducing the amount of hazardous and toxic substances.

There are several ways of encouraging the population to participate in a waste minimization programme. The following offer only a few ideas of such strategies.

Information and awareness campaigns

These should serve to teach governments and the public about the problems associated with MSW management and the importance of waste minimization as a tool for MSW management. To ensure the implementation of any waste reduction programme, the involvement of the local population is necessary to increases the chances of success of such a programme. These campaigns should include methods of waste reduction, recycling and materials re-use that are suitable at household or village level.

Study of waste characteristics.

By conducting a comprehensive waste characterization, it is possible to analyze the various types of waste and to see where waste can be minimized at source.

Encourage source-separation, recovery, re-use, recycling

Curbside collection is used in several European and North American cities. They have proven effective in most cases. In Asia, curbside collection is not common mainly because, the collected waste is sorted by local populations that need this income for survival. Hence, waste is sorted in trashcans, in collection trucks, at transfer stations and at landfill sites. Restrictions on waste separation would certainly jeopardize the livelihood of thousands of families and therefore, it has become a social problem rather than just a MSW management issue. Nevertheless, curbside collection, special truck collection and collection in shopping malls may be a direction worth considering for the future development of Asian tropical cities. Meanwhile, waste pickers should be encouraged to continue the work they are doing while following health and safety guidelines as to minimize the risks associated with waste handling.

Waste reduction by enforcement of specific legislation

Specific legislation can be formulated to address issues such as packaging and hazardous substances. This can be achieved by installing special taxes on specific products. For example, deposits for glass bottles, aluminum cans, and PET bottles. Moneys from these surcharges can then ensure that the waste is returned for recycling and/or re-use.

Limitations or bans on imports are also a way of reducing the amount of HHMSW produced.

Facilitate export of recyclable materials

Products such as aluminum cans, used tires, and various types of plastic may not be recyclable within the country of use. Therefore, these can be exported in countries where environmentally compliant recycling techniques are used. The Basel Convention regulations must be observed for all trans-movement of waste from one country to the others (see Annex IX for Basel Convention text and notifications on household waste).

Re-use of products

Many products can be re-used for very different purposes. For example, in Bangkok used tires are used to make floor mats, flowerpots, and garbage bins. In Vietnam, old aluminum soft drink cans are transformed into model cars, airplanes and other items to be sold to tourists.

3.2.4 WASTE TRANSPORT COLLECTION EFFICIENCY

COLLECTION AND TRANSPORT

Waste collection is generally ensured by municipalities. People are required to leave the waste in bags or in bins in front of their houses, where it is collected by the municipality's waste collection truck. In some countries, such as in Vietnam, waste is swept into small piles, and is then collected by a municipal worker pushing a cart. This cart is then brought at the end of the road or lane where it is loaded onto a garbage truck that brings it to the treatment plant, may it be a compost plant or a landfill site, depending on the type of waste collected, and the location.

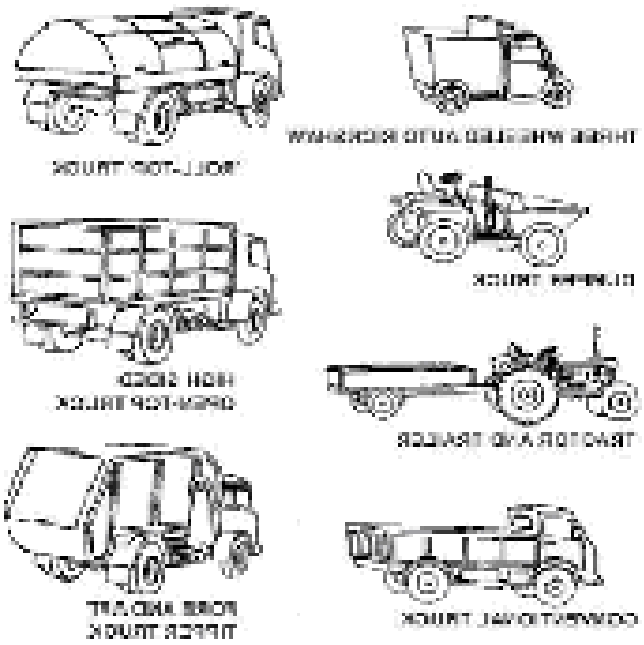
Selection of the appropriate type of collection vehicle is crucial to ensure maximum collection efficiency. In many countries, roads are too narrow to allow the generally used 10-tonne trucks. Therefore, smaller trucks, tricycles, bicycles or carts are required to ensure collection. Another way is for people to bring their waste in a large bin located at the end of the road or in specific locations where these bins can later be collected by a larger truck. This is the case in Sierra Leone. Nevertheless, the efficiency of such a collection system needs to be proven since in the country's capital Freetown, most of the waste is dumped in streams, or water canals where it is washed to sea, or dumped on a vacant land where it is eventually burned in open air, releasing toxic dioxins and furans. People are not always in a position or willing to bring their waste to the disposal bins and therefore they revert to dumping. Therefore, many landfills are born around the country.

Collection trucks must also be appropriate to the terrain, and to the type, and density of the waste, to the roads and their conditions, to the strength and capability of the workers, and to the location and distance between collection and final disposal sites. Moreover, capital investment, operating and maintenance costs must be carefully evaluated while

availability of technical expertise required for operating, and maintaining the equipment along with the availability of spare parts must be taken into consideration. A vehicle type already operating in a country is usually favorable.

The following shows some of the various collection vehicles used for the collection of MSW.

Figure 3 Types of vehicles used for waste collection in various countries



Source: UNCHS (Habitat) (1999): Transfer of Appropriate Technology, Semi-Aerobic Landfill Method: Fukuoka Method.

Waste collection bins

Waste collection bins play a key role in a city or country's cleanliness. These bins can be locally made from recycled materials. Some municipalities are using recycled tires, while others use 200-liter oil drums cut in half. What is important is that these bins are easily identified and that they are placed in strategic areas to ensure that waste is thrown in the bins rather than the streets or waterways. This means they should have a special shape, color, or marking. They should be sturdy and easy to maintain, repair, or replace. To encourage waste segregation, many municipalities opted for different colored bins, for different types of waste. For example, green bins for putrescent waste, yellow for inert materials such as plastic and glass, while grey and/or red for hazardous substances such as spray cans and used batteries. These bins must all be waterproof, dog proof and designed to withstand strong winds for those areas where high winds are prevalent, and flood proof for most tropical countries.

Route design and operation

There can be significant differences in the type and length of routings from one municipality to another. Moreover, although the responsibility for collection falls under the municipality, services can be ensured by municipal workers, public authorities or by a private company. Overall, the collection operation should cover the whole service using the least amount of capital investment, labor, and time.

Several factors must be considered when preparing a routing plan. These can be summarized as follows:

- Collection should be done when traffic on the roads is at its lowest.
- The quantity of waste collected must be calculated as to maximize the time of collection and transport from collection point to disposal site.
- The spread of vehicles and transport from collection point to disposal.
- The spread of vehicles on the agglomeration of collection points. In rural areas, vehicles should move faster.
- The frequency for collection must take into account the volume of waste, the size of containers, local preferences, and climatic conditions. In hot and humid countries, more frequent collections are necessary to minimize health hazards and foul smell.
- Curbside collection reduces the time for collection.
- Centralized collection reduces even more the time for collection.
- Special collection is often used for large and bulky waste such as old appliances, electronics, furniture and construction materials. The frequency for these collections varies according to need.

Transfer stations

Transfer stations are used as a relay station where waste is brought in from smaller collection trucks, reloaded into larger lorries, and taken to the processing plant or landfill site for final disposal. Transfer stations are feasible when:

- There is considerable distance between collection and final disposal
- They can be used for sorting and segregation of waste for recycling, reuse, and separation of HHW materials
- They are capable of accommodating all collection trucks
- Can be used as a buffer for temporary storage
- The site also includes a transformation centre such as a compost plant.

Transfer stations require additional capital investments, additional handling, and special management. Its location is crucial since it must serve as a mid-point between source

collection and final disposal. It must also have no negative impacts on neighboring properties due to noise, smell, dust, and traffic.

Transfer technologies

Various types of transfer technologies can be used. These include:

Table 10 Different transfer technologies

Type of Transfer Technologies	Potential use in SIDS (small island developing states)	Comments
Large truck and trailer units	Not likely	– Likely to be oversized for most SIDS applications. *(and for most small communities in any country)* – Single high-sided trucks may be most appropriate.
Barge (sea and water)	Good potential	– Where waste is to be disposed of on another island. – Presents possible problems with loosing waste to sea (or in waterways in other countries) during the voyage and when transferring on and off the barge
Open tipping floor	Most suited to SIDS (in developing countries)	– More efficient for small volumes of waste. – Allows waste sorting materials recovery and transfer of materials onto different vehicles for different destinations.
Open Pit	May be suited in some cases	– Similar to tipping floor but is not ideal for sorting and recovery of materials. – Has higher capital and operating costs and is more vulnerable to breakdown
Direct dumping	Not recommended in SIDS (nor for developing countries)	– Collection trucks unload through hoppers directly into larger transfer sites. – Does not permit sorting and recovery of materials. – Trucks requires high equipment maintenance repair and replacement

Source: Adapted from UNEP Directory of Environmentally Sound Technologies for waste management in Pacific SIDS

The collection of MSW requires careful planning and good logistics. Because waste needs to be collected from each household, each apartment building, each office and each commercial complex and location, frequency of collection needs to be well planned

with specific routings for each truck involved in waste collection. Collection also includes the hauling of waste to a transfer station or to the location where transformation takes place, or to a disposal site where the trucks dump their content.

The number of trucks and labor required is determined by the amount of waste to be collected, the distance to be covered and the time spent at each collection point.

3.2.5 WASTE SEPARATION

Separation of waste can be done manually or mechanically. Because of the low labor costs in many tropical Asian countries, manual separation is favored, although it is often preceded by a sorting trommel, which separates bulky materials. Manual sorting is an effective method of segregating recyclable materials such as paper, cardboard, glass and plastic. It is also used as a pre-treatment for compost and anaerobic digestion systems as to ensure that only green and fermentable waste is allowed into the process.

In mechanical screening, various types of screens can be used. These include:

- Vibrating screens: to remove undersized materials
- Rotary screens: Also, known as trommel or rotary drum screens to separate waste materials into several fractions
- Disk screen: Used to separate materials into several size fractions
- Density separator: Also, known as air classification, it is used to separate light materials such as plastic and paper from heavier materials such as metals.
- Magnetic separator: Used to separate ferrous from non-ferrous metals.

3.2.6 PROCESSING AND PREPARATION

Processing is a method used to facilitate the manipulation or transformation of waste. It does not change the composition of the waste but rather changes its overall property such as size, water content and density. These processes include:

- Densification: Also referred to as compaction, it allows an increase in the density of waste to be transported or stored. Densification systems include compacting, baling, cubing and pelletizing.

- Crushing: Devices used to crush cans and metal items, increase their density while reducing their size, and consequently transport costs.

- Dewatering: The quantity of water found in waste can be reduced with the use of several dewatering systems. These include the belt press, the filter press and the centrifuge. An evaporator or dryer can also be used to heat the waste while evaporating its water content.

3.2.7 COMPOSTING

Composting is the chemical transformation of organic matter through the decomposition of organic matter into their constituents under aerobic or anaerobic conditions. The process can be summarized as follows:

Fresh organic matter + H_2O water (liquid) + energy (turning)
=> Compost + CO2 + NH_3 + heat + steam

As a result, the value of waste is reduced and a by-product, namely humus, is produced and can be used to provide the soil with nutrients.

Compost plants include several process stages:

1. Reception and physical separation of waste (ranging from simple to complex systems, labor intensive or fully mechanized, depending on the type of waste and investments
2. Transformation of waste into compost
3. Air treatment
4. Refining of compost
5. Long term storage (over several months)

To achieve feasibility and the making of good quality compost, specific conditions need to be met according to size. To ensure the feasibility of the compost plant, choosing the right size is of significant importance since capital investment and operating costs are proportional to the size of the plant; the performance of the plant must be optimized.

Less than 2 tonnes per day organic matter

For such a small system, backyard composting can be established at household level. This system uses heaps of compostable materials such as kitchen scraps, paper, grass cutting and other garden waste. These are placed in the composting container or in heaps. The main costs associated with this system are community sensitization and eventual training on composting. Some municipalities also offer composting containers to encourage this activity. Homeowners must ensure turning of the heaps using forks.

Between 2 and 5 tonnes per day

A small neighborhood compost plant can be established with members of the community collecting and bringing the compostable waste to a central location for processing. There must be an agreement within the community or the neighborhood in order to function properly.

This system requires minimum investment and can be done in plastic or concrete bins that are filled one after the other and emptied upon maturation. Turning needs to be

ensured by someone. Although a step up from backyard composting, it is basically the same system but on a slightly larger scale because at a neighborhood level.

5 – 50 tonnes per day

For this amount of organic waste, a village or local community project is suitable. Systems for this scale include the same basic system as used in backyard and neighborhood level, but can also use a windrow system. It can be managed by the local community authority or by individuals. Good fencing is necessary to ensure that no animals enter the premises. Waste is to be brought by individuals or can be collected from curbside bins or by the municipality's collection trucks. Although a community level project, it is a low cost solution. Nevertheless, to ensure the feasibility of the project, utilization of the compost must be ensured. This can often be organized with municipal parks and community gardens that need compost. Golf courses may also be users of compost.

Over 50 tonnes per day

Mechanical systems such as windrow are recommended for larger volumes as to ensure good quality compost. The quality of the end product is determinant to ensure the feasibility of the compost plant. Other methodologies can also be used, according to local requirements, climate, labor and financial resources.

3.2.7.1 COMPOSTING METHODS USED

Several composting methods have been developed over the years, each having its advantages and disadvantages. The type of waste to be composted, the climatic conditions under which composting is to be done along with the size of the compost plant and availability of funding are key issues that help determine the type of composting most appropriate for a municipality.

The following table reviews several composting techniques used around the world, including Thailand, as to demonstrate their applicability for various environments and needs.

Table 11 Summary of main composting methods used

Method	*EM technology*	*Indore or heap method*	*Pit method*	*The Bangalore Method*	*The Berkley Method*	*Vermi Composting*	*Passive windrow*	*Turned windrow*	*Aerated static pile*	*In-vessel channel*
Type of waste used	organic waste	Mixture of plant residues, animal dung and urine, mixed with earth, wood, ash and water	Mixed bedding from the cattle shed dung slurry	Night soil and refuse	Waste	Organic matter	Compostable materials	Compostable materials	Compostable materials	Compostable materials
Technological level	Low technology	Low technology, quality problem	Low technology, quality problem	Low technology, quality problem	Low technology, quality problem	Low technology, quality problem	Low technology, quality problem	Medium technology.	Medium to High technology	High technology
Plant size requirements for feasibility	Small	Small	Small	Small	Small	Small to medium plants	Small to medium plants	Medium to large plants	Medium to large plants.	Large municipal and commercial plants
Applicability	Private or village level	Private or village level	Private or village level	Private or village level	Private or village level	Private, village, farm or small municipality level	Private, village, farm or small municipality level	Active systems most common on farms	Effective for farm and municipal use	Large-scale systems for commercial applications
Labor	Labor required	Labor required	Labor required	Labor required	Labor required	Labor required	Labor required	Increase with aeration frequency and poor planning	System design and planning important. Monitoring needed	Requires consistent level of management/product flow to be cost efficient.
Site	Requires little land areas	Requires large land areas	Requires large land areas	Requires large land areas	Requires large land areas	Requires large land areas	Requires large land areas	Can require large land areas	Less land required given faster rates and effective pile volumes.	Very limited land, due to rapid rates and continuous operation

Method	*EM technology*	*Indore or heap method*	*Pit method*	*The Bangalore Method*	*The Berkley Method*	*Vermi Composting*	*Passive windrow*	*Turned windrow*	*Aerated static pile*	*In-vessel channel*
Active period	3 – 6 months	3 – 6 months	3 – 6 months	3 – 6 months	4 weeks	2 – 4 month	6 – 24 month	21 – 40 days	21 – 40 days	21 – 35 days
Curing	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	30 + days	30 + days	30 + days
Size Height Width Length	Usually, EM mixed with waste in big bags	~ 1.5 meter ~ 2 meter ~ 3 meter (Vary)	~10 to 15 cm ~1.5 to 2.0 m variable	15 – 20 cm - variable - variable	~1.5 m ~2.4 m ~2.2 m	~1 m ~3 m ~4 m	- 1 to 4 m - 3 to 7 m - variable	- 1 to 2.8 m - 3 to 6 m - variable	- 3 to 4.5 m - variable - variable	- Depend on bay - - - - - design - variable - variable
Aeration system	Natural degradation	Natural degradation	Weekly manual turning	Natural degradation	Weekly manual turning	Natural degradation	Natural degradation	Mechanical turning and natural convection	Forced positive/negative air flow through pile	Extensive mechanical turning and aeration
Process control	Initial mix only	Initial mix only	waste thoroughly mixed, moistened with water	Initial mix only	Initial mix only	Initial mix only	Initial mix only	initial mix, turning	initial mix aeration, temperature and/or time control	Initial mix, aeration, temperature, and/or time control, turning
Odor factor	Odor will occur but when in closed bags, odor is controlled.	Odor from the heaps will occur. The larger the heaps the greater the odors	Odor from the heaps will occur. The larger the heaps the greater the odors	Odor from the heaps will occur. The larger the heaps the greater the odors	Odor from the heaps will occur. The larger the heaps the greater the odors	Limited odor due to immediate conversion of waste into castings.	Odor from the windrow will occur. The larger the windrow the greater the odors	Form surface area of windrow. Turning can create odors during initial weeks	Odor can occur, but can be controlled with pile insulation or filtered air system	Odor can occur, often due to equipment failure or system design limitations
Investment cost	Low	Low	Low	Low	Low	Low	Low	Medium	High	High

Technical requirements and investment costs remain the two most important factors when considering composting. These must be taken into consideration when selecting a composting technology. Moreover, the quality of compost is determined by the quality of waste entering the system. Therefore, special provisions for should be made available for the segregation of compostable materials.

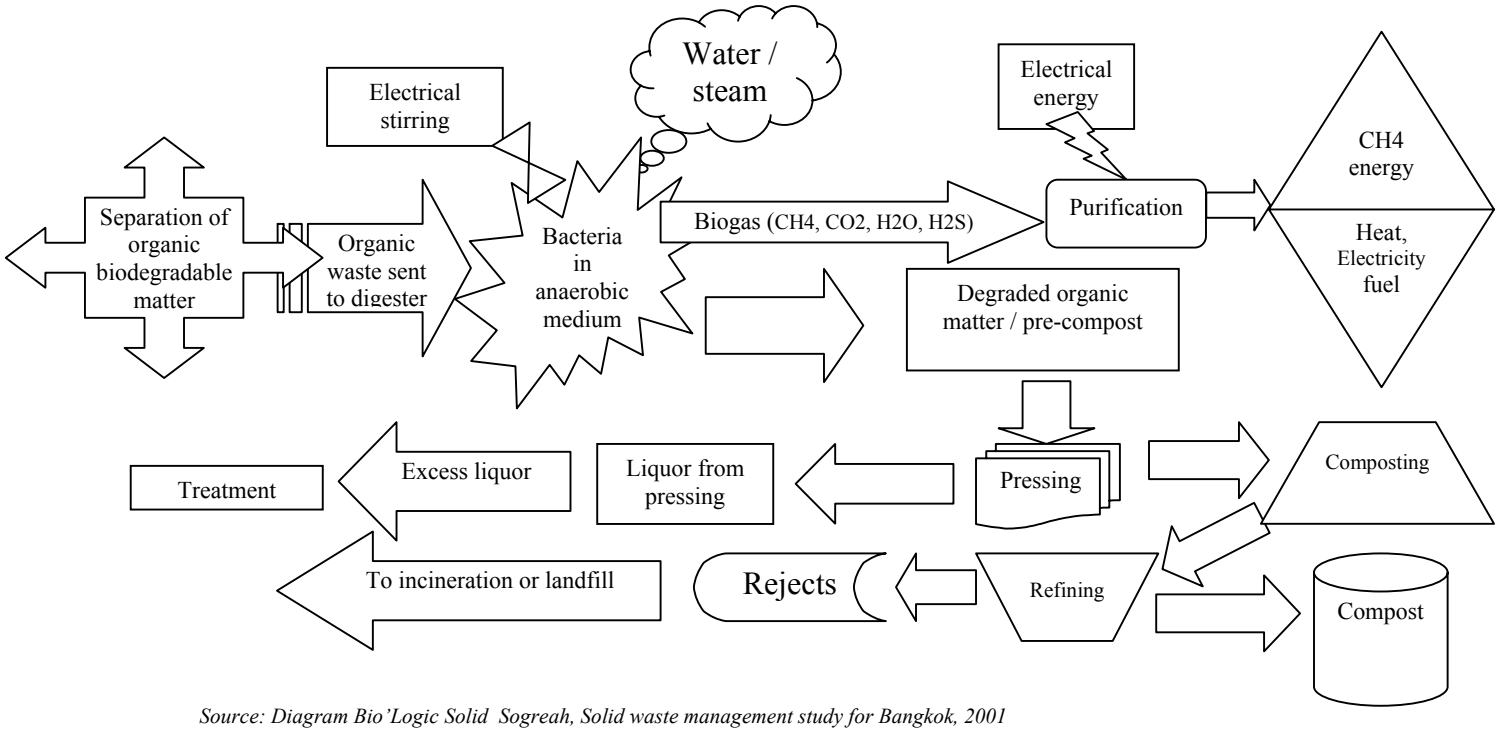
3.2.8 ANAEROBIC DIGESTION

The biodegradable fraction is degraded in an anaerobic manner, in absence of oxygen, with the use of a complex group of bacteria that derive their energy from the degradation of waste. The main objective of anaerobic digestion is the production of biogas as an alternative energy source. The overall process can be summarized as follows:

Fresh organic matter + energy (heating, stirring) => Pre-compost + CH_4 (=energy) + CO_2 + NH_3 + heat + water (liquid)

The following diagram shows the principle and various stages of the anaerobic digestion process.

Figure 4 Basic principle of anaerobic digestion



Source: Diagram Bio'Logic Solid Sogreah, Solid waste management study for Bangkok, 2001

The nature and the proportion of the various waste components (kitchen waste, food scraps, paper, cardboard, green waste) have a direct impact on:

- The quantity of biogas produced and its methane content
- The quantity of stabilized organic matter remaining following treatment
- The quantity of liquid and water produced

Treatment of waste in anaerobic digestion can be done under various conditions.

- Under mesophilic condition (around $35^oC – 40^oC$)
- Under thermophilic conditions (around $50^oC – 55^oC$)
- In a liquid (with up to 10 – 15% dry matter)\Under solid conditions with a high level of dry matter content (with around 25 – 35% dry matter)
- In batches in a closed fermentor where the waste is loaded and left for a duration of 3 – 5 weeks
- On continuous basis where the waste is loaded each day and withdrawn each day.

The result of anaerobic digestion is the production of biogas, thus creating a positive energy balance. Anaerobic digestion treatment systems are energy producers that can be used in different forms:

- Heat production as hot water or steam, through combustion in a water heater
- Electricity either as stand-alone or in co-generation (electricity + heat) through a generator or a gas turbine
- Fuel for vehicles following purification and compression.

Energy production from anaerobic digestion

With the increasing prices of oil and gas, not to mention the continuous depletion of fossil fuel, the conversion of waste into alternative fuels is becoming an increasingly attractive option for waste disposal.

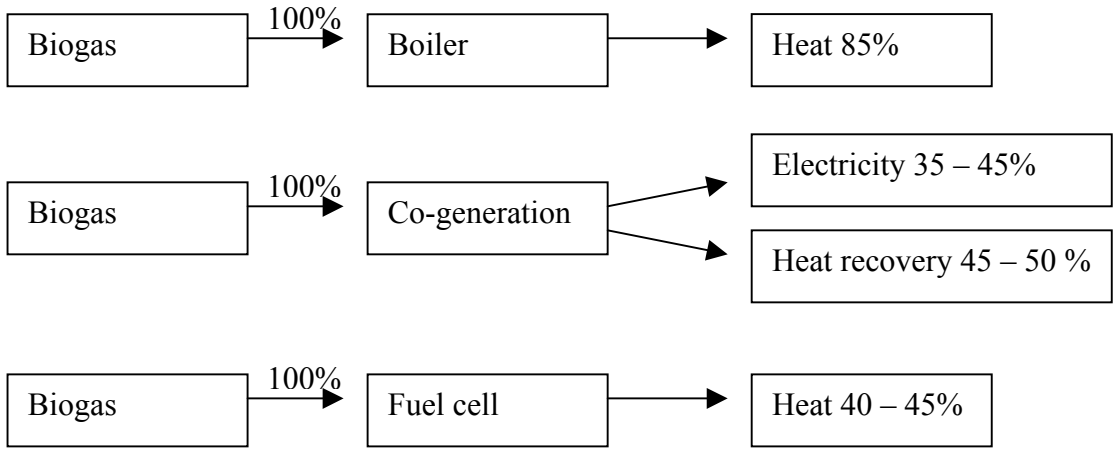
One can estimate that one tonne of household waste can produce 76 – 130 Nm^3 of quality biogas containing approximately 55 - 65% methane, or between 150 – 200 kWh per tonne of material.

As such, 2,000 tonnes of municipal solid waste can be converted into 1 GWh of electrical power while avoiding the production of approximately 1,000 tonnes of CO_2 if this organic waste was sent to landfill. This further reduces transport costs from the collection or transfer station to the landfill, the costs associated to land-filling, and it also minimizes the greenhouse gases that would otherwise be produced in the landfill, which is 21 times more potent than CO_2.

The methane's High Heating Value (HHV) is 11.07 kWh/Nm^3 while its Low Heat Value (LHV) is 9.96 thus the ratio LHV/HHV = 0.90. One should remember that the quantity

of energy produced per tonne of waste depends on the quality of waste, the type of system used and the type of energy produced (i.e. gas, steam, heat).

Figure 5 Energetic potential from biogas under different energy production systems



Source: Sogreah, Solid waste management study for Bangkok, 2001

Based on the above assumptions, it is possible to conclude that for an average theoretical quantity of biogas of 90 Nm^3/tonne produced and 60% methane content (medium value) per tonne of waste, the energy produced could be:

- Potential heat production: 90 (Nm^3) X 60% (methane) X 11.07 (HHV) X 0.9 (ratio)= 538 kWh (or 1,937 MJ) / tonne of waste

- Heat or steam from boilers: 538 kWh X 85% (efficiency) = 457 kWh (or 1,645 MJ) per tonne of waste

- Electricity generation

Using a gas engine: 538 kWh X 40% (efficiency) = 215 kWh per tonne of waste

Using a gas turbine: 538 kWh X 30% (efficiency) = 161 kWh per tonne of waste

- Co-generation heat recovery) from exhaust gases and the cooling of internal fluids (water and/or oil)

Using a gas engine: 538 kWh X 45% (efficiency) = 242 kWh (or 871 MJ) per tonne of waste

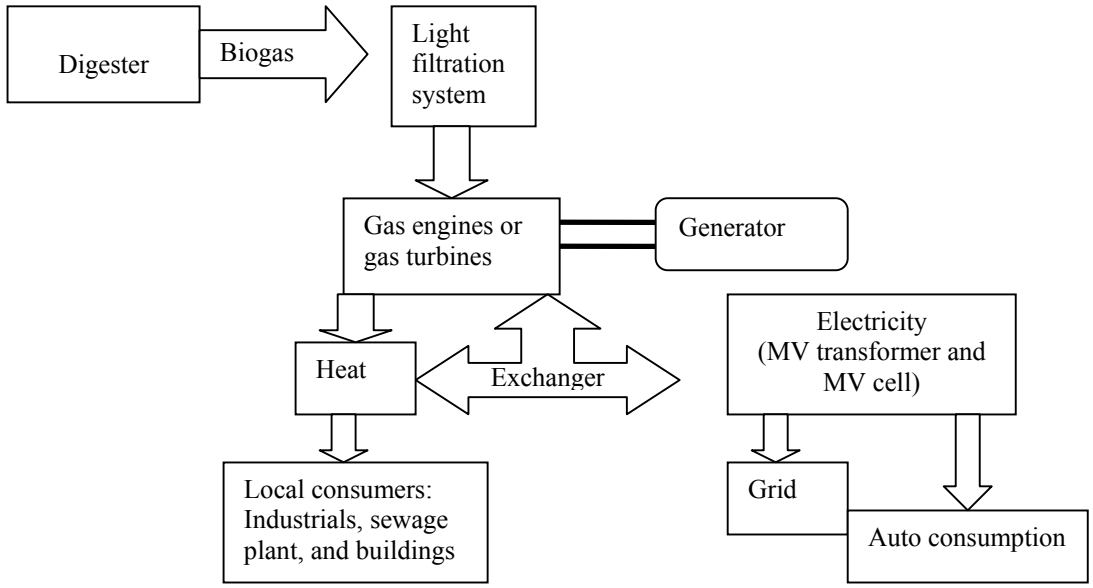
Using a gas turbine: up to 538 kWh X 50 % (efficiency) = 269 kWh (or 968 MJ) per tonne of waste

A biogas power generation plant consists of:

- A filtration system to eliminate particles and contaminants from the gas
- Either a gas engine or a gas turbine connected to a generator
- A boiler with its exchangers and a water feeding pump (optional)
- A Medium Voltage transformer and one MV cell
- Mechanical auxiliaries (oil, air, water-cooling, etc.)
- Electrical auxiliaries, instrumentation and control

The following is an example of a biogas power generation plant:

Figure 6 Typical biogas power generation plant

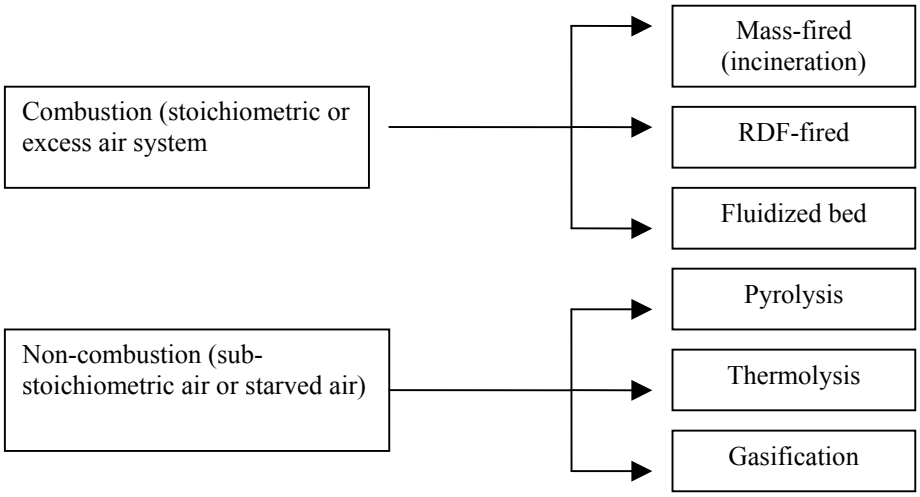


Source: Sogreah, Solid waste management study for Bangkok, 2001

3.2.9 THERMAL TREATMENT

Thermal processing is the conversion of waste into gaseous, liquid and solids using heat and releasing heat energy. There are two main types of thermal processes, which are categorized based on the quantity of air or oxygen used.

Figure 7 Thermal treatment-processing systems



3.2.9.1 COMBUSTION SYSTEMS

The combustion system or incineration can be defined as the use of fire to break down the waste into lower components such as gas, and ashes. The main advantage of combustion is high volume reduction that can reach over 95% of the original volume.

The main disadvantage of combustion systems is the quantity of emissions that are often toxic such as PCDDs and PCDFs, which are formed in the presence of chlorinated substances associated with organic compounds. It is possible to minimize these environmental impacts by installing high performing air pollution control systems. Nevertheless, these systems are extremely costly and can reach over 30% of the total value of the incineration plant. The fact remains that incineration destroys the organic and combustible fractions of the waste thus reducing the volume of waste significantly. However, the remaining fly ashes and slag contain an accumulation of all toxic chemicals and heavy metals that were included in the incinerated waste, and that have not been released into the atmosphere. These ashes therefore require disposal in secured landfills or specialized stabilization, solidification or vitrification to eliminate the possibility of leaching into the environment.

Hazardous materials such as mercury containing waste must be eliminated during sorting, prior to entering any heat treatment system. Heavy metals cannot be destroyed in incineration and therefore increase the costs associated with a high performance Air Pollution Control system.

Energy and heat can be recovered from combustion plants in the form of steam and heat, and further converted into electricity.

3.2.9.2 NON-COMBUSTION SYSTEMS

Non-combustion systems were developed with the objective of breaking-down organic matter using heat, and producing re-usable by-products. MSW can therefore be converted into gas, oil and char.

The main advantage of the non-combustion systems is the low or inexistent emissions. Because by-products are used as valuable recovered raw materials, all are collected and therefore never released into the atmosphere. In non-combustion systems, heavy metals are dispersed in the char, usually in trace levels. Careful pre-treatment sorting is therefore necessary to minimize these toxic substances.

The disadvantage of these systems is that the volume of residual solid matter, namely the char, remains high; up to 30% of the initial volume remains as a solid substance. The quantity of gas, oil and char produced will depend on the feedstock, on the temperature during treatment and on the pressure in the non-combustion system vessel. These can be adjusted as to maximize one by-product rather than another.

Non-combustion systems can be associated with boilers, turbines and other electricity producing devices as to produce energy.

3.2.9.3 ENERGY RECOVERY

Energy recovery is an efficient way of offsetting operating costs, although the additional components of the system such as heat exchangers do increase the cost of the system significantly. Depending on the composition of waste and its humidity level, heat and steam can be generated. By controlling the input waste, and eliminating the presence of chlorinated waste, the formation of dioxins and furans is reduced if not totally eliminated. The low temperature of below 600^{o}C used in non-combustion systems minimizes or eliminates the possible formation of PCDD and PCDF. In the same way, high temperature incineration, at levels above 1,200^{o}C will also break down the elements necessary to the production of PCDD and PCDF, thus minimizing or eliminating their formation.

Factors to be verified when considering a thermal treatment system:

1. Siting
2. Air emission
3. Disposal of residues
4. Liquid emissions
5. Financial requirements

Siting:

There is increasing negative opinions regarding combustion and therefore siting is becoming problematic. The NIMBY (Not In My Back Yard) syndrome has reached Asia and is now responsible for having halted several combustion systems from being constructed. Ideally, combustion systems should be located outside the cities, far from any housing area. Unfortunately, these systems are often compared to coal fired power plants that are often highly polluting. Close collaboration with local communities is therefore the only way a combustion system could be established in any Asian city. The distance from the collection point to the treatment plant must also be taken into consideration. Since most of the collected waste is coming from the municipality, transport costs increase proportionally to the distance, not to mention all risks associated with the transport of waste. Finally, for the plant to generate steam if too far from the users of steam it is impossible to sell the steam; steam cannot travel long distances (maximum 6 kilometers).

Air emission:

Combustion cannot occur without the emission of various gases and particulates, which may have a very severe negative impact on health and the environment. Nevertheless, technology offers highly efficient air pollution control systems such as wet and dry scrubbers, bag house filters, cyclones and multi-cyclones, which eliminate most if not all of the toxic emissions. These air pollution control systems are necessary and must be part of the design of the combustion system. The main problem with these systems is their costs, which may range from 50% to 100 % of the cost of the combustor in order for the emissions to comply with the increasingly stringent international standards. Each country has its own standards but in many Asian countries, USEPA or EC standards are used. The European standards can be found in Annex I. In the cases of a non-combustion system, some treatments such as gasification use a minimal amount of air or oxygen and therefore will generate some emissions that also need to be treated. Generally, all gases are carefully captured and used for energy production and therefore, not allowed to be released into the atmosphere.

Disposal of residues

Following combustion, ultimate residues remain and must be eliminated. These include bottom ashes, and by-products from the scrubber. These residues are often highly toxic since they contain a concentrated form of contaminants including heavy metals. Therefore, residues must be disposed of in a secured landfill as to eliminate any possibility of leaching into the ground and groundwater. Increasingly, these residues need to be stabilized and often solidified through solidification processes, before being placed into landfills. Stabilization/solidification processes include Petrifix (France), Chemfix (USA) and Inertec (France) to name only a few. They can also be vitrified for complete inerting and elimination of leaching.

Non-combustion systems do not produce any solid residues. These systems produce high amounts of char, which can be sold as a by-product or further refined to produce carbon black.

Liquid emissions:

Every thermal system produces liquid emissions. These may originate from the cleaning, flushing and general housekeeping from pump seals, ash removal, wet scrubbers, from the treatment system to produce high-quality boiler water, or from a cooling tower. All this wastewater must be treated according to its properties and contaminants, prior to its release into the environment.

Financial requirements:

The capital and operating costs for thermal treatment depend on the type of waste entering the system and the quantity of by-products that can be sold. In high humidity countries such as tropical Asian cities, the quantity of fuel required per tonne of waste can be very high. Special drying systems and source separation by eliminating the organic fraction offer means of reducing the quantity of fuel necessary for start-up combustion. It should be noted that 1,162 MJ of energy is required to evaporate one kg of water [Resources naturelles et al, 2002]. By combining combustion with a system such as composting, the two can benefit from each other. The most feasible method is certainly to convert the waste into energy. However, until now, this energy efficiency process needs to be proven on small, medium and large scales.

Table 12 Estimated ranking for capital investment costs of MSW treatment

Type of system	Capital investment costs Lowest cost 1 to 6 highest cost
Composting	2
Anaerobic digestion	4
Non-combustion systems (Pyrolysis, thermolysis, gasification)	5
Incineration	3
Landfill	1
Waste to energy	6

3.2.10 RECYCLING

Recycling has become increasingly popular the world over. The percentage of recyclable materials can be determined through a well-conducted waste characterization. Yet, the local governments are the ones who determine which percentage of the recyclable materials should be reached. These are generally stated in the local environment plans, which are meant to minimize the quantity of waste at source, with the goal to lower the overall disposal costs.

A significant amount of waste can be recycled. Some studies claim that 100% of the waste can be recycled and /or reused. Although this may appear somewhat optimistic, in theory, it can be done, with a cost. The feasibility of recycling has often been over-estimated. The fact is that the costs associated with recycling are often so high that the recycled material becomes more expensive than the original item. All recyclable products have market prices that vary according to supply and demand. The sale of recyclable materials can often subsidize part of the waste treatment plant within a community, or can at least contribute to the financial offset or repayments of the waste treatment plant. The following table shows some of the items that are recycled and that can generate income if collected for recycling:

Figure 8 Items selected for recycling

Recyclable material	Types and origins
Organic matter	Food waste, green waste, market waste
Plastic	PVC, PE, PET, PP
Paper	Plain white, glossy,
Cardboard	Packaging,
Wood	Garden waste, wood industry waste
Textile	Household, industries
Rubber	Household, industries
Leather	Household, industries
Glass	Clear glass, colored glass
Metals	Iron, steel
Non-metals	Aluminum
Stones and ceramic	Household, construction, demolition
Construction/demolition waste	Household, construction sites

3.2.11 LANDFILL

To landfill is to place waste in an especially designed areas, which allows the monitoring of the incoming waste, its disposal, its compaction, and the control of all leachate and gases produced in the landfill. The term “cell” is used for the area where solid waste is deposited and covered at the end of the day. There is increasing concern about landfilling and legislation in many countries obliges municipalities to pre-treat the waste prior to disposal. This means that all putrescent matters, which decay and produce methane and CO_2, must be removed from the waste prior to landfilling as to ensure the

prevention of fugitive emissions associated with greenhouse gases and global warming. This implies that in many cases, it is not possible to send waste directly from the collection truck to the landfill site. Landfill should be used primarily for residual waste, after it has been processed through composting, anaerobic digestion, recycling, and/or thermal treatment.

The costs associated with landfill are also rising with an increasingly demanding environment, which requires the capture of landfill gas, treatment of leachate, and specific provision for capping, closure, and post-closure monitoring. There is increasing interest in the use of landfill gas as a source of energy and therefore income.

The identification of a site for landfill requires careful consideration. The European Landfill Directive (see Annex II) says that the location of a landfill must take into consideration:

1. The distance from the boundary of the site to
    a. Residential and recreational areas
    b. Waterways
    c. Water bodies
    d. Agricultural areas
    e. Urban sites
2. The existence of groundwater, coastal water or natural protection zones
3. The geological and hydrogeological conditions
4. The risk of flooding, land subsidence, landslides or avalanches
5. Protection of the natural or cultural heritage in the area.

Therefore, a landfill can only be authorized if it does not pose any environmental risk in relation to the above-mentioned parameters.

Size

The size of the landfill must be calculated based on the quantity of projected waste over a period of 20 -30 years. A 25-year life is generally used. The landfill should calculate a total height of waste of a maximum of 20 meters and a slope of 1:3.

The site must also secure a perimeter of 100 meters for a buffer zone.

Hydrogeological conditions

The site must be selected as to ensure that the soil's natural conditions offer the lowest permeability of soil and rock.

Sites should be far from groundwater tables. A landfill liner should be designed to uplift the pressure. In conformity with European standards, the landfill site for non-hazardous waste should have a clay layer with thickness > 1m and permeability of $K \leq 10^{-9}$ m/s (as

per EC COUNCIL DIRECTIVE 1999/31/EC of 26 April 1999 on the landfill of waste, Section 3.2 – see Annex II).

Water and leachate control

All landfill sites generate wastewater and leachate, which need to be managed. It is therefore necessary to install a wastewater system for the treatment of rainwater entering the landfill and for the leachate produced, prior to discharge. Surface and groundwater should not be allowed to enter into the landfill. Moreover, in order to reduce hydraulic pressures on the geosynthetic liner and to prevent leakage, leachate must be properly collected and evacuated. Perforated drainpipes are used and are made to resist overburden pressures thus ensuring that the hydrostatic pressures from leachate on the geosynthetic liner do not exceed 0.3 meters [Sogreah, 2001].

All leachate must be collected and stored in a lined pond nearby the landfill. Leachate shall then be treated using evaporation, reverse osmosis, chemical treatment or any other suitable system. Because leachate is site specific, the wastewater treatment plant must be built according to water specifications following its analysis.

Runoffs and rainwater either infiltrates the landfill and becomes leachate, or runs on the surface of the landfill and becomes contaminated. It must therefore be channeled to the same pond and treated as leachate. Its analysis is required prior to discharge into the environment or public sewer.

A storm-water trench should be built around the landfill site as to capture outside storm-water and avoid its entrance onto the site.

Landfill lining

The lining in a landfill is probably the most important part of the landfill since its quality and engineering ensure the protection of soil and groundwater from potential contaminants found in the landfill. The type and design of liner used in a landfill depend on the type of water that is to be stored in the landfill and the hydrogeological conditions of the location.

It is necessary that the geosynthetic membrane ensure resistance to puncture, tensile stress, and chemical attack. The most often used and appropriate type of lining used is therefore high-density polyethylene (HDPE). Thickness is determined by local regulations.

The liner must be placed on a smooth surface free from sharp or protruding objects. The surface should consist of compacted clayey soil.

Lining can also be ensured by a geocomposite membrane consisting of a layer of HDPE and bentonite clay backing. Because bentonite swells when in contact with water, it is considered as self-sealing, and can be used without the 0.6 m low permeability soil layer, thus saving on the total thickness of the liner.

Soil and groundwater protection

The soil and groundwater table must be totally protected from any contamination generated by the landfill. This is done using a geological barrier (usually clay) and a liner (geomembrane, plastic sheeting) that line the bottom of the landfill prior to its operation. A top liner should also be installed following closure.

The type of soil where the landfill is to be located is determinant. According to the EC regulations, the following requirements must be met, according to the category of landfill.

Table 13 Soil permeability levels according to EC regulations

Class of landfill	Permeability	Barrier thickness
Class 1. Hazardous waste	$K \leq 1.0 \times 10^{-9}$ m/s	b ≥5m
Class 2. Non-hazardous waste	$K \leq 1.0 \times 10^{-9}$ m/s	b ≥1m
Class 1. Inert waste	$K \leq 1.0 \times 10^{-7}$ m/s	b ≥1m

Source: EC COUNCIL DIRECTIVE 1999/31/EC of 26 April 1999 on the landfill of waste

When the barrier thickness is in accordance with the above, it can be compensated by an artificial/synthetic barrier. However, the natural barrier should never be less than 0.5 m in thickness.

Landfill gas control

Landfills generate large amounts of biogas due to the natural degradation of organic matter. When this degradation occurs in anaerobic conditions, the biogas becomes increasingly rich in methane while the level of CO_2 decreases. This is associated with ozone depletion because of the greenhouse effect. Several countries have signed or ratified the Kyoto and Montreal Protocols (see Annex III and VI), which require the minimization of gas emissions. Moreover, uncontrolled biogas generates objectionable odors due to the presence of mercaptans (CH_4S) not to mention the dangers of explosion associated with the accumulation of methane. Therefore, landfill gas should be collected, treated and either used when in sufficient quantity, or flared when in small quantity.

A good system for the collection of biogas when dealing with thick layers of waste is using vertical wells to penetrate the numerous intermediate cover layers and remove gases from the most isolated (anaerobic) corners of the landfill. These vertical wells must be made to withstand pressure due to settlement of the waste and the corrosive nature of the gases.

Spacing between wells should not exceed 70 meters for efficiency. Spacing of 50 meters and approximately four wells per hectare are recommended (Sogreah, France). Once the final cover is installed, all wells are to be connected to a gas collection network and adjusted according to need and settlement of the waste. A vacuum pump shall ensure a

negative pressure. The gas can then be cleaned and used in a generator or flared when in insufficient quantity. Under no circumstances should the gas be allowed to be released into the atmosphere without treatment.

Landfill cover

In order to minimize the quantity of leachate produced in the landfill, a landfill cover is generally used. Depending on the country and on the local regulations, a soil cover of at least one meter is used on the top of the landfill. Normally, an impermeable geomembrane is also used and covered by another meter of soil. This prevents the rain from entering the landfill and stops the gas from escaping from the landfill. The top of the cover should be slightly domed to avoid low points in the middle part, which are associated with various soil settlements.

The top cover should take into consideration the local climate and should blend with existing local vegetation. This vegetation should be applied rapidly as to avoid erosion and top soil washing. An additional layer of soil is to be placed between the vegetation and the geosynthetic liner to prevent the build-up of water pressure and to prevent the erosion of the plant layer.

Energy recovery

Landfill gas can be extracted and converted into energy. This serves several purposes.

1. Avoidance of emissions of biogas containing high levels of methane into the atmosphere.
2. Avoidance of CO_2 emissions.
3. Reduction in the quantity of fossil fuel used.
4. Production of clean electricity.

3.3 RESOURCE RECOVERY EFFICIENCY AND RELATED HEALTH HAZARDS

For many countries, mining of municipal solid waste is a main source of income for many poor city dwellers in need of survival. Therefore, resource recovery from municipal solid waste becomes a key factor as an income generating activity. However, associated health and hazard risks need to be evaluated.

In many Asian cities, municipal solid waste is dumped without segregation alongside hospital and infectious waste. This creates high health hazards with waste pickers injuring themselves on used contaminated needles and encountering hospital waste ranging from umbilical cords to severed limbs. These health hazards should be addressed through the control of hospital and infectious waste since the elimination of waste pickers in most city dwellings is virtually impossible.

Formal sorting at source remains one of the easiest controls for governments. These can be found in certain cities and towns, where color-coded waste bins are used to collect paper, cardboard, glass and food waste. Some cities also have a hazardous waste bin, which allows the collection of used batteries, spray cans and neon lights.

3.4 HOUSEHOLD HAZARDOUS WASTE MANAGEMENT

Hazardous waste management is necessary to avoid contamination of waste, especially if composting is utilized. This household hazardous waste comprises of spray cans, paint, batteries, household insecticide, neon lights, chlorinated detergents and more. The separation and disposal of such waste should be ensured prior to the transformation of waste into compost, or before entering crushing and incineration, as to avoid contamination, explosions and other related accidents.

3.5 DETERMINING WASTE CHARACTERISTICS FOR APPROPRIATE TREATMENT

Waste characterization remains one of the most important issues, prior to decision-making on waste disposal. Food habits, culture, level of social and community development will be determinant of the differences in the types and quantities of waste produced. The level of humidity in the waste will also play a key role in the determination of the better-suited waste treatment to be utilized. For example, if the waste humidity level is very high due to high level of organic materials, incineration is most likely to be too expensive, unless associated with a pre-treatment for drying, which may in turn be too costly for a developing country.

3.6 ENVIRONMENTAL IMPACT ASSESSMENT

The impact of a new waste treatment facility needs to be assessed prior to its establishment. The impact on the environment can be in the air, in the water (nearby waterways, groundwater table), in the soil. It can also be on the local community because of the noise, the dust and even the visual intrusion associated with the establishment of a waste treatment plant.

Many of these negative impacts can be mitigated through appropriate technologies and site preparedness. However, as for everything, there is a cost and this cost must be evaluated as to its feasibility and workability in the selected community. Developing countries usually have low budgets and therefore, the environmental impacts are often by-passed allowing contamination, which will need to be addressed in a more or less near future. Such neglect should not be allowed in any country. In a globalizing world, pollution of air or water in one country can easily mean pollution in a neighboring country. Such practices are not acceptable in the 21st century.

3.7 SUSTAINABILITY OF SELECTED SYSTEM

Sustainability of a system is ensured by evaluating the expansion and population growth of the local population, changes of habits and economic development. When selecting a

waste disposal system, its flexibility remains an important criterion. Moreover, recycling practices may have a direct positive or negative impact on the selected system. For example, the increase of plastic bags will have a positive impact on the calorific value of waste for an incineration, but recycling of this plastic will decrease the calorific value and therefore may increase the operating costs of an incinerator to a point where it becomes too costly to operate. Therefore, laws, regulations and targets for various disposal practices need to be well evaluated and planned prior to the selection of a waste treatment system in order to ensure its sustainability.

3.8 CONVERTING WASTE INTO ENERGY

Waste to energy systems have been around for decades and have proven that they can be feasible, depending on the type and quantity of waste to be treated. Energy can be produced in various forms, including steam, heat, carbon and gas. Although gasification offers the highest ratio of waste to energy, the costs associated to the systems are often prohibitive to developing nations. Moreover, in tropical climates, the level of humidity contained in the MSW makes any thermal system expensive to operate because of the energy required to heat and break down the waste into its various components.

Incineration has become a least preferred waste disposal option in many countries because of its negative image. However, if associated with energy production, thermal treatment systems such as pyrolysis and thermolysis could become an economically sensible option for the future with their zero emissions.

3.9 FINANCIAL ISSUES

It is estimated that the urban areas of Asia spend about US$25 billion on solid waste management per year; this figure will increase to about US$47 billion in 2025 [Hoornweg, D. and L. Thomas., 1991]. It is estimated that people in developing countries produce between 0.5 and 1 kg per person per day of solid waste. Costs associated with the collection, transfer and disposal of the waste range between US$ 20 and US$ 60 per tonne of MSW, with the cost of collection taking 70% of the total costs. This is most likely underestimated since two key factors involved and subjective are the cost of land for disposal and political issues due to community resistance regarding the setting-up of garbage disposal facilities in their proximity. As such, one can estimate the cost of waste management in developing countries to be about US$ 5 per capita per year [Hammer - Chiu 2002]. Thus, a city of 200,000 persons will spend at least one million dollars per year on MSW management. Unfortunately, in many large cities of developing countries, a large number of people living in the city are slum-dwellers and therefore cannot afford to pay for waste disposal. Financing therefore has to come from central governments and for some municipalities, on local advertising and city taxes. Because waste management generally does not show return on investment, financing becomes more difficult to obtain. The cost-benefits, however, do exist in the form of improved health and increased tourism, and therefore should be considered in a business plan.

3.10 SECTION SUMMARY

Waste is and has always been a result of daily life activities. However, the decreasing amount of land available for MSW treatment and disposal is directly proportional to the increase in population. Therefore, alternative and integrated MSWM plans are now necessary to ensure sustainable waste management. Identification of the key issues in waste treatment and disposal is crucial to understanding the local needs. These needs may differ from one country to another. These include a review of the level of economic development, which has a direct relation to the quantity and quality of waste. Geographical aspects are also key factors in the selection of waste treatment systems. These include siting, topographical information, climatic conditions, and review of existing environmental programmes.

Human development is also important as to verify the flexibility of the selected system. With increased population will come increased waste generation and possible changes in the characteristics of the waste. Population density must also be taken into consideration in order to develop proper infrastructures necessary for the collection and transport of waste.

The produced waste characteristics will determine the technical constraints of the selected treatment system, or its combination. These characteristics include waste volume, density, moisture content, combustibility, recyclability, and the presence of hazardous waste.

The social impact of a treatment plant must always be carefully analyzed. Therefore, community participation is encouraged as to protect cultural practices, health issues, and encourage employment generation with special consideration for the poor, the women and the children. Resource recovery and its social and political implications must take into consideration the law, regulations, their implementation and enforcement. Private sector participation is certainly a key to the success of the implementation of a new waste treatment plant.

Technical issues play an important part in the selection of the “right” system; municipal administrators generally favor waste reduction programmes. Efficient collection and transport systems are necessary to ensure maximum coverage. These can be facilitated with the use of specific waste collection bins, appropriate design and operation routes, transfer stations and transfer systems. Waste separation is done mechanically and more frequently manually. This allows the segregation of wanted and unwanted materials, thus allowing a better performance of the selected waste treatment system. Biological transformation of waste offers an effective means of reducing the impact of waste on the environment; both composting and anaerobic digestion offer specific advantages and disadvantages. One of the main advantages of composting and anaerobic digestion when compared to incineration is that it is a more feasible solution when it comes to waste in tropical countries. Waste in tropical countries has high moisture content and low calorific value making incineration a costly solution to waste disposal. Combustion and non-combustion system can also be an appropriate manner of disposing waste. With combustion, the volume of waste can be reduced by up to 95%. Non-combustion systems are generally seen as more environmentally friendly, with little or no emissions. Both can offer energy production, which is often needed in small townships in emerging

and developing countries. Landfilling must be well prepared as to avoid soil and groundwater contamination. This can be done with the use of geomembranes with a high-density clay site. Energy can also be produced from the landfill gas.

Resource recovery from MSW is an important factor as an income generating activity. Health hazards should be addressed for populations involved in waste sorting and through the control of hospital and infectious waste as to eliminate their presence in municipal landfills.

The separation and disposal of municipal hazardous waste should be ensured prior to the transformation of waste into compost, or before entering crushing and incineration, as to avoid contamination, explosions and other related accidents. Waste characterization is a necessary step prior to decision-making as to determine the waste's composition, its moisture content and flammability.

Environmental impact assessments are also highly recommended prior to the establishment of a new treatment plant, in order to verify the potential negative impacts on the community and its natural environment. The flexibility of the selected treatment plant will also ensure its sustainability, viability and environmental compliance.

Waste to energy systems may be an answer to the need for electricity of certain communities. Through incineration or non-combustion systems, energy could be sold as steam, heat, carbon or gas, and therefore could offer an economical opportunity to the community.

Finally, but not least important, financial considerations are necessary prior to the selection of a treatment plant as to ensure that the population is in a position to pay the required "garbage collection fee". People in developing countries produce between 0.5 and 1 kg per person per day of solid waste. It is estimated that the disposal of this waste will cost each person approximately US$ 5.00 per year. With higher technology come higher prices. In any event, MSW management will not offer a direct return on investment. However, it will allow an indirect return through the citizens' improved health, cleaner environment and potential higher incomes through increased tourism.

4. Data collection: Bangkok's municipal solid waste management

4.1 General description

From 1999 to 2002, the author jointly with the French environmental engineering firm Sogreah has conducted an extensive study on the quantity and type of MSW generated in Bangkok. All data was collected during formal interviewing with BMA officers, government officers or through hands-on verification including waste characterization, site visits and laboratory testing. Although the data is a few years old, there has been no significant difference in the quantity and quality of waste generated in the Bangkok metropolitan area. With the problems associated with the local politics, a coup in 2006 and a current threat of bombs in various locations, Thailand, although fully recovered from the Asian crisis, is now somehow at a sluggish state, attempting to resolve its internal problems. Few recent environmental studies have been conducted and therefore, data have been updated based on its availability.

4.1.1 Geographical and social context

Thailand has a total Area: 513,115 km^2, of which 40% is agricultural and cultivated land, 2% is used as pastures, 26% are forests and woodlands, and 32% is for others. Over 49,860 km2 [CIA, 2006] is irrigated land.

The country is divided into six topographical regions and into 76 provinces. Each province is divided into districts.

Figure 9 Map for location of Thailand

Bangkok is the capital of Thailand; it has a total area of 1,565.2 km^2. There are approximately 9 million persons living in Bangkok, which accounts for fifteen percent of the country's total population of over 64.63 million people [CIA, 2006]. Of these 9 million people, only about half are registered in the capital while the others are temporary migrant and laborers coming from the provinces to work as taxi drivers and in factories.

Population density varies widely in the country with Bangkok having the most population. In 2002, Bangkok had a population density of over 3,500 persons per square km, whereas Bangkok metropolitan had a density of 1,246 persons per sq.km. These numbers are quite high when one compares the other parts of the country: Central part: 180 persons per sq.km; Eastern part: 118 persons per sq.km; Western part: 85 persons per sq.km; Northeastern part: 127 persons per sq.km; Northern part: 72 persons per sq.km; Southern part: 119 persons per sq.km.

4.1.2 ROADS AND TRANSPORT

Thailand has one of the best road and transport system in Asia, which facilitates communications and trade. Thailand has 4,000 km of waterways of which 3,701 km are navigable by boats with drafts of up to 0.9 meters. It has a railway system of 4,071 km of which 4,071 km with 1.000-m narrow gauge. The country has a total of 57,403 km of roads, of which 56,542 km are paved and 861 km are unpaved [CIA, 2006]. Waste can therefore be handled properly giving accessibility to waste collection trucks around the country.

4.1.3 ECONOMIC DATA

Thailand is now considered as an emerging country. The minimum daily wage in Thailand: THB 170 (~US$ 4 as of January 1st 2004)

GDP per capita: THB 86,473 (US$ 2,060) (2002) and a GDP growth rate: 5% (2002).

GINI coefficient of household: 43% (2002) and the GINI coefficient of person: 51% (2002), which shows the disparity of income among the Thai population.

4.1.4 CLIMATIC INFORMATION

Thailand has a tropical climate with high temperature and humidity year round.

Table 14 Climatic information according to the season

Description	Winter	Summer	Rainy	Annual
Average temperature	26.1 °C	29.5 °C	28.2 °C	
Mean maximum temperature	31.5 °C	35.3 °C	32.5 °C	
Mean minimum	20.9 °C	24.3 °C	24.7 °C	
Extreme temperature Maximum				43.9 °C (1958, 1983)
Extreme temperature Minimum				5.2 °C (1993)
Seasonal rainfall	130.0 mm	192.3 mm	907.4 mm	113 days of rain (total)
Relative humidity	71 %	69 %	79 %	73 % (mean)
Frequency of tropical storms	20	2	20	22 (total)

Table 15 Average rainfall and temperature for Bangkok 1999

Month	Rainfall (mm)	Average Temperature (°C)
January	35.1	27.8
February	52.3	28.1
March	50.9	30.3
April	189.6	29.7
May	409.6	28.6
June	104.1	29.1
July	72.3	29.6
August	158.7	28.9
September	211.2	28.6
October	383.8	28.0
November	88.1	27.7
December	0.5	21.5
Total annual	**1,756.2**	**28.1**

4.1.5 HYDROGEOLOGICAL CONTEXT

The city of Bangkok is located in the Lower Central Plain of the Chao Phraya River Basin, the main river in Thailand, which flows into the Gulf of Thailand.

Table 16 Aquifers in Bangkok Metropolitan areas

Hydrological Classification	Depth (m)	Aquifer Water Quality
Bangkok Clay (soft clay)	1.5 – 1.7	
Bangkok Clay (Stiff clay)	17 – 20	
Bangkok Aquifer	20 – 58	Brackish
Phra Pradaeng Aquifer	58 – 122	Often brackish
Nakhon Luang Aquifer	122 – 178	Good, principle groundwater supply
Nonthaburi Aquifer	178 – 281	Excellent, highly productive
Sam Kok Aquifer	281 – 361	Excellent, Low Fe content
Phayathai Aquifer	361 – 440	Excellent but deep
Thonburi Aquifer	440 – 483	Excellent but deep
Pak Nam Aquifer	440 - < 600	Excellent but deep

Source: Ministry of Environment and Mineral Resources, Groundwater Division

4.1.6 SEASONAL ASPECTS

Bangkok has a tropical climate with yearly monsoon season. It is classified into three main seasons: The rainy season, which runs from May to October, the cool season, from November to January and the hot season from February to April.

The average temperature for Bangkok registered in 1999 was 28.4^{o}C with the highest temperatures registered between 1990 and 1999 being 33.3^{o}C and the lowest average temperature being 24.9^{o}C.

Wind velocity is very low in Thailand with an average of 4.68 km per hour, which does not make a conducive environment for wind power.

As for all tropical countries, humidity is high throughout the year, reaching its maximum during the rainy season. In Thailand, humidity ranges from 70 – 100%. This is an important factor when considering waste treatment. For example, incineration may become very costly because of the high level of moisture contained in waste, which is due to the high content of organic waste associated with the humid environment and the high levels of rain especially during the monsoon season. However, bacteria find the

climatic conditions of high temperature and moisture content an ideal environment for multiplication, thus creating a suitable environment for composting.

Table 17 Bangkok climatic conditions

Climatic condition	Unit	Level
Average temperature	^{o}C	28.4
Highest registered	^{o}C	33.3
Lowest	^{o}C	24.9
Wind velocity	km/h	4.68
Humidity	%	70 - 100
Annual rainfall (2001)	mm	1,764.5
Days of rain (2001)	Days	131

Source: Meteorological Department of Thailand

4.2 PRODUCTION OF MSW

4.2.1 WASTE PRODUCTION SOURCES

BMA is responsible for the collection of all MSW produced in Bangkok. All industrial waste falls under the responsibility of the Ministry of Industry. During the year 2000, BMA collected 3,283,905 tonnes of waste, with an average of 8,997 tonnes per day. There is an average increase in the quantity of waste of approximately 2.3% per year. The main sources of MSW are households, industries, hospitals, hotels, restaurants, fresh markets, schools, shopping centers, and parks and garden.

Household waste

The quantity of waste generated per household ranges from 0.33 kg to 1.54 kg /person/day, with an average of 1.00 kg/person/day. The MSW generated per flat or apartment is between 0.20 and 1.15 kg/persons/day with an average of 0.57 kg/person/day. Condominiums generate between 0.23 and 1.09 kg/person/day with an average of 0.71 kg/person/day. Approximately 45% of all MSW generated comes from households.

Ordinary industrial waste

Ordinary industrial waste is estimated at between 0.03 kg to 5.16 kg/person/day, with an average of 0.06 kg/person/day.

Hospital waste

Hospital waste includes infectious, hazardous and non-hazardous waste. An estimated 0.22 to 6.45 kg/bed/day of normal waste is produced, with an average of 2.03 kg/bed/day. Hospitals produce 0.06 to 0.59 kg/bed/day of potentially infectious and hazardous waste, an average of 0.30 kg/bed/day. All together, in the year 2000, there were 141 hospitals in Bangkok with about 27,000 staff and 28,094 patient beds.

Hotel waste

Hotels produce between 0.10 to 1.58 kg/person/day of waste, with an average of 0.490 kg/person/day, which are equivalent to 1.83 kg/room /day. In the year 1999, there were 245 hotels for 55,845 rooms. Altogether, 8,780,029 people recorded an average stay of 2.24 days and an occupancy rate of 55.04%

Restaurant waste

Restaurants produce 0.49 kg/person/day or 0.97 kg/employee /day

Fresh market waste

Fresh markets around Bangkok produce between 0.25 kg to 1.00 kg/m2/day, with an average of 0.62 kg/m2/day. BMA collects waste generated from about 140 markets around the city.

School waste

Schools and academic institutions produce between 0.02 to 0.57 kg/person/day. There are about 1,493 schools in operation with 1,016,543 students and 5,324 teachers.

Shopping centers, offices and department stores

It is estimated that commercial and office premises produce 0.01 to 0.24 kg/m^2/day, with an average of 0.05 kg/person/day.

There is an estimated 70,000 business establishments in Bangkok; employing 3,165,070 persons of which 38% in restaurants, 39% in offices, 17% in factories and others 6%.

Parks, gardens and street sweeping waste

Environmental conservation has become an increasing concern for the BMA and as such, several park projects were developed. As of the year 2000, there was already 8 million m^2 of parks and gardens around the city. There is therefore an increasing amount of green waste and a growing need for soil conditioner and fertilizer, which may create a good opportunity to encourage composting.

Table 18 Waste production by source

Source of waste	Unit	Quantity	Average
MSW from households	kg /person/day	0.33 - 1.54	0.72
MSW from flats/apartments	kg /person/day	0.20 - 1.15	0.57
MSW from Condominiums	kg /person/day	0.23 - 1.09	0.71
Ordinary industrial waste	kg /person/day	0.03 - 5.16	0.06
Hospital waste (general)	kg/bed/day	0.22 - 6.45	2.03
Hospital infectious and hazardous waste	kg/bed/day	0.06 - 0.59	0.30
Hotel waste	kg/person/day	0.10 - 1.58	0.49
	kg/room /day	n/a	1.83
Restaurant waste	kg/person/day	n/a	0.49
	kg/employee /day	n/a	0.97
Fresh markets waste (green waste)	kg/m^2/day	0.25 - 1.00	0.61
School waste	kg/person/day	0.02 - 0.57	0.30
Commercial/office waste	kg/m^2/day	0.01- 0.24	0.13
	kg/person/day	n/a	0.05
Parks and garden waste (green waste)	Per m^2	n/a	n/a

Source: Thailand in Figures, 7th Edition 2004

4.2.2 AMOUNT OF WASTE PRODUCED

The average quantity of waste produced per inhabitant for Bangkok is estimated at 1.5 kg per day. This is calculated based on the amount of waste collected divided by the number of inhabitants. Although this figure is not exact, it is a good way of estimating the quantity of waste produced. For the municipality of Bangkok, the quantity of waste generated per inhabitant ranges from 1.2 to 1.8 kg per person, depending on the area, thus an average of 1.5 kg per inhabitant. This amount of waste is the amount of waste collected and not the amount of waste produced, since some of the waste may have been sorted before its collection, either by the homeowners, or by itinerant waste collectors referred to in Thailand as *Saleng (three-wheeled collection carts)*. Moreover, it is necessary to verify the collection efficiency. If the percentage of waste collected is not equal to 100%, then the amount of waste per inhabitant must be reduced in proportion.

In order to predict waste production changes over a period of time, the rate of increase in population must also be calculated as to allow the forecasting in the increase or decrease of the quantity of waste to be collected.

It is estimated that Bangkok has a population growth of between 0.2 – 0.4% per year (see table 19), thus it is estimated that the number of registered people in Bangkok by the year 2015 should reach around 6 million people. Nevertheless, these figures only show the number of people registered in Bangkok, not the actual number of people living in Bangkok. With the level of rural exodus towards the big city, this number is most likely to more than double this amount since the unofficial number of inhabitants in 2003 was close to 11 million people. This means that the quantity of waste produced per day can well reach 20,000 tonnes by the year 2015.

Table 19 Increase in Bangkok population 1992 – 2015

YEAR	POPULATION	ANNUAL GROWTH	POPULATION	ANNUAL GROWTH
1992	5,562,141.00	0.20%	5,562,141.00	0.40%
1993	5,573,265.28	0.20%	5,584,389.56	0.40%
1994	5,584,411.81	0.20%	5,606,727.12	0.40%
1995	5,595,580.64	0.20%	5,629,154.03	0.40%
1996	5,606,771.80	0.20%	5,651,670.65	0.40%
1997	5,617,985.34	0.20%	5,674,277.33	0.40%
1998	5,629,221.31	0.20%	5,696,974.44	0.40%
1999	5,640,479.75	0.20%	5,719,762.34	0.40%
2000	5,651,760.71	0.20%	5,742,641.39	0.40%
2001	5,663,064.24	0.20%	5,765,611.95	0.40%
2002	5,782,159.00	0.20%	5,788,674.40	0.40%
2003	5,793,723.32	0.20%	5,811,829.10	0.40%
2004	5,805,310.76	0.20%	5,835,076.41	0.40%
2005	5,816,921.39	0.20%	5,858,416.72	0.40%
2006	5,828,555.23	0.20%	5,881,850.39	0.40%
2007	5,840,212.34	0.20%	5,905,377.79	0.40%
2008	5,851,892.76	0.20%	5,928,999.30	0.40%
2009	5,863,596.55	0.20%	5,952,715.30	0.40%
2010	5,875,323.74	0.20%	5,976,526.16	0.40%
2011	5,887,074.39	0.20%	6,000,432.26	0.40%
2012	5,898,848.54	0.20%	6,024,433.99	0.40%
2013	5,910,646.24	0.20%	6,048,531.73	0.40%
2014	5,922,467.53	0.20%	6,072,725.85	0.40%
2015	5,934,312.46	0.20%	6,097,016.76	0.40%

Seasons also have a direct impact on the people's behavior and consequently, on the quantity and type of waste generated. In special tourist areas, for examples resort cities near the ocean, the quantity of waste may vary tremendously from one season to another. This can make a significant difference in the quantity and type of waste generated, from one season to another.

Seasonal interference can be calculated from the quantity of waste collected as follows:

1. The lowest month (M_1) must be excluded to ensure reliability of date.
2. The average of the lowest six months is calculated

$$X_1 = \frac{M_2 + M_3 + M_4 + M_5 + M_6 + M_7}{6}$$

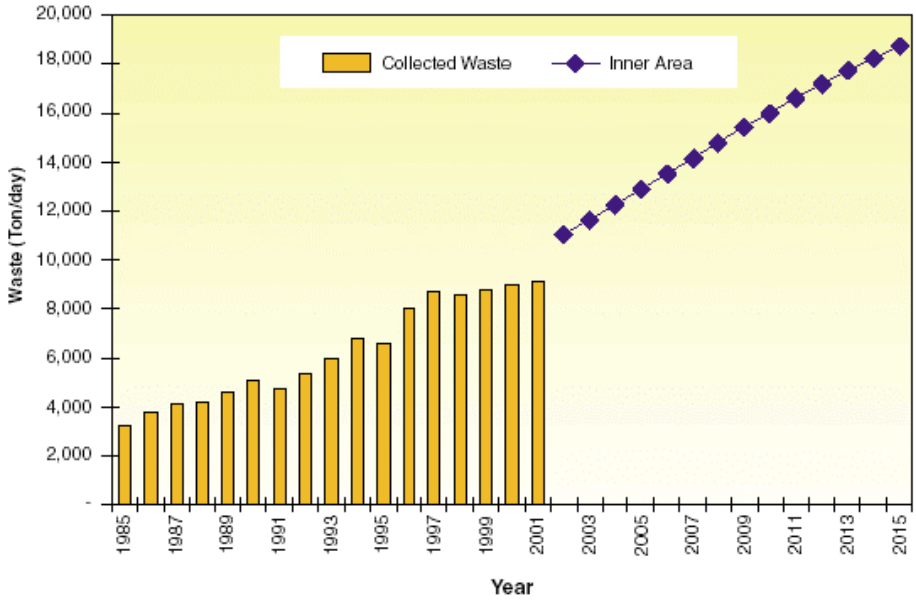
3. The average X for the 12 months is then calculated. Then the amount of waste produced each month is divided by the X_1 to verify the seasonability of the month. If the ratio is higher than 1.5, the studied zone has a seasonal activity.

X / X_1 <1.5 = no seasonal activity X / X_1 >1.5 = presence of seasonal activity

Tourism has a direct impact on the quantity and quality of waste generated based on its seasonal activities. In a country such as Thailand, there is an estimated 15 million visitors [Wikipedia, 2007] visiting the country and arriving in Bangkok, many staying for an average of 2.1 days in over 55,000 hotels.

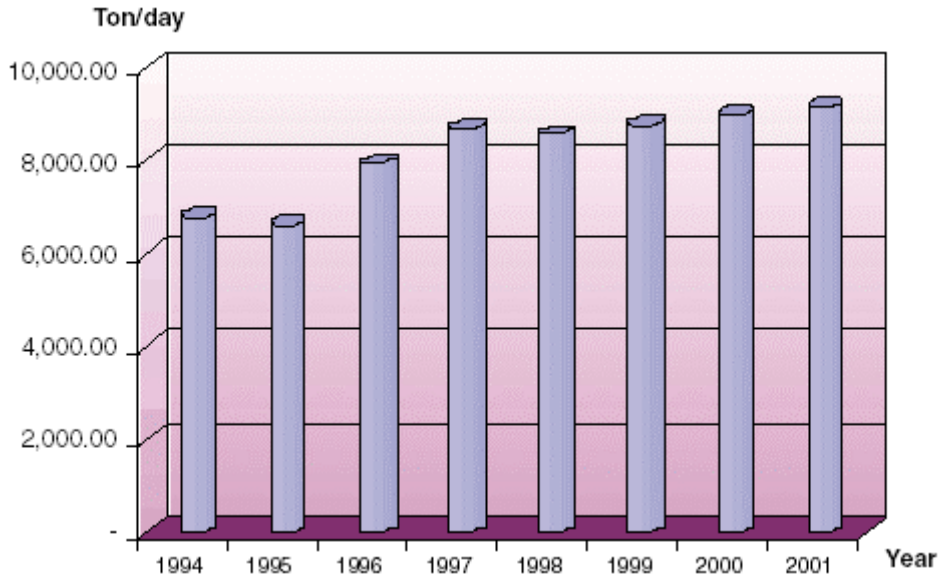
In Bangkok, waste is collected and transported to a transfer station. There, the truck is weighed on a weighbridge as to verify the quantity of waste entering the station. The city of Bangkok generates approximately 9,000 tonnes of waste daily. The quantity has more than doubled in the past 15 years. This increase is associated with a higher population, modified consumption pattern and changing lifestyle as seen in Figure 10 and Figure 11.

Figure 10 Waste increase from 1985 – 2015



Source: UNEP, State of the environment 2001,

Figure 11 Waste generated from 1994 - 2001



Source: UNEP, State of the environment 2001,

4.3 COLLECTION AND TRANSPORT OF MSW

Collection is organized by schedule. In certain municipalities, these schedules are weekly, and for others, it is daily. To determine the collection schedule, it is necessary to take values on a weekly basis (not counting holidays or special events). Special collections for selective items such as large size household appliances, steel, glass, paper, must be taken into consideration. Meetings with city officials allowed the determination of the most representative routings, including a range of habitats, including office areas, residential areas, higher income areas, medium income and lower income areas.

4.3.1 TYPE OF HOUSING AND ECONOMIC ACTIVITIES

The type of housing is determined according to the number of apartments or households:

- Buildings with 1 apartment/household only
  - Farm
  - Single house
  - Others
- Buildings with 2 apartments/households
  - Townhouse
- Semi-detached house
- Others

- Buildings with 3 – 4 apartments/households
- Buildings with 5 – 9 apartments/households
- Buildings with 10 – 19 apartments/households
- Buildings with 20 or more apartments/households

Economic activities also influences the type of waste generated. These can be divided in the following categories:

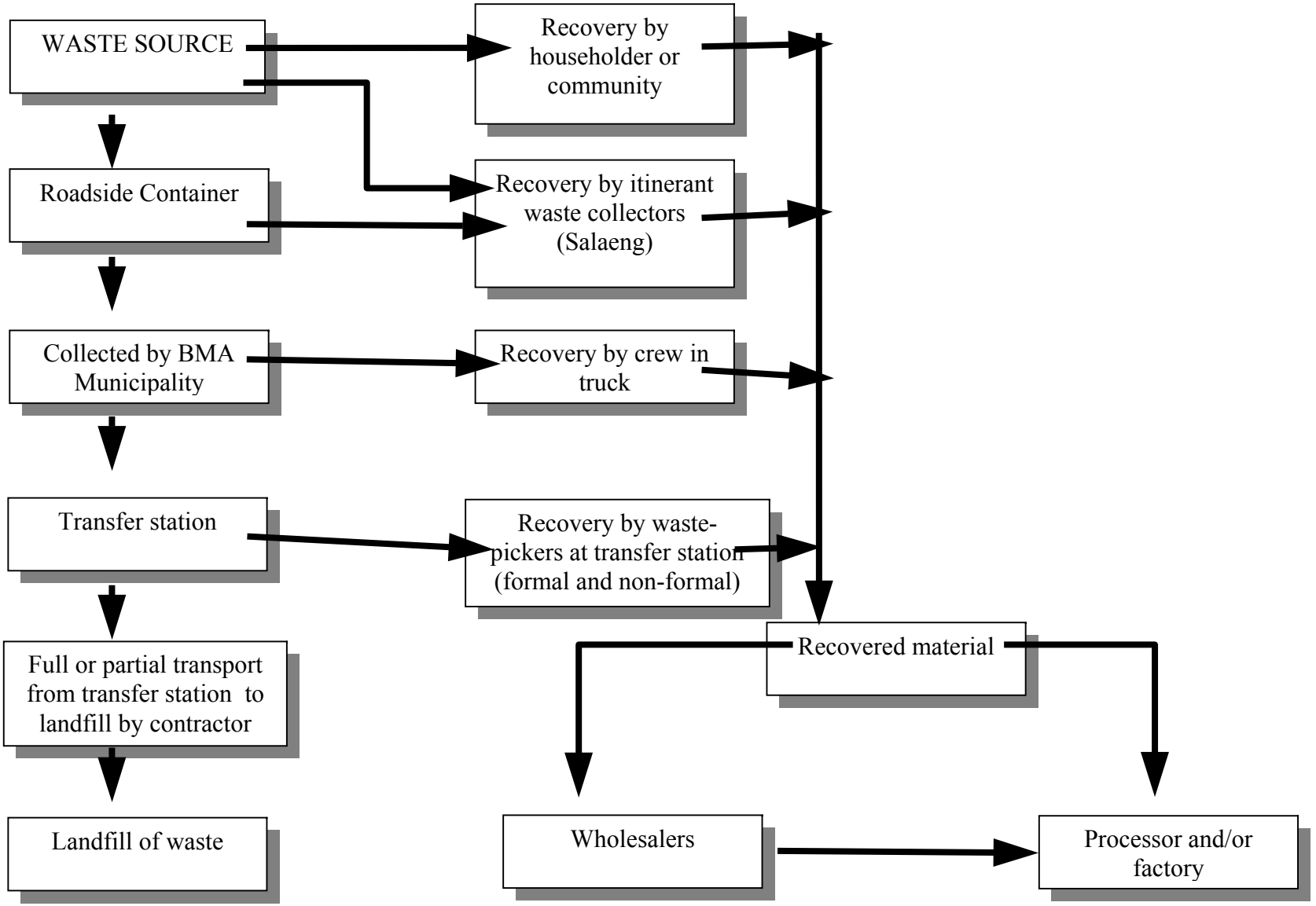
- Agriculture, forestry, fishing
- Agriculture and food industries
- Energy production and distribution
- Trading industries
- Equipment supply industries
- Consumer products industries
- Construction and agricultural civil engineering industries
- Commerce
- Transport and communications
- Commercial services
- Real-estate development
- Insurances
- Financial organizations
- Non-commercial services

Bangkok Metropolitan includes suburb areas where some agricultural fields can be found. Most of Bangkok, however, is commercial and residential.

4.3.2 COLLECTION AND TRANSPORT SYSTEM

The collection and transport system in the BMA can be summarized in Figure 12.

Figure 12 Collection and transport organizational chart



4.3.3 WASTE COLLECTION VEHICLES AND EQUIPMENT

There are 2,400 collection vehicles collecting waste from BMA's 50 districts. BMA is investigating the transformation of some of its collection trucks in CNG (compressed natural gas) or in dual fuel systems (gas and CNG). This project is supported by the National Energy Policy Organisation (NEPO) with funding from the government energy saving fund.

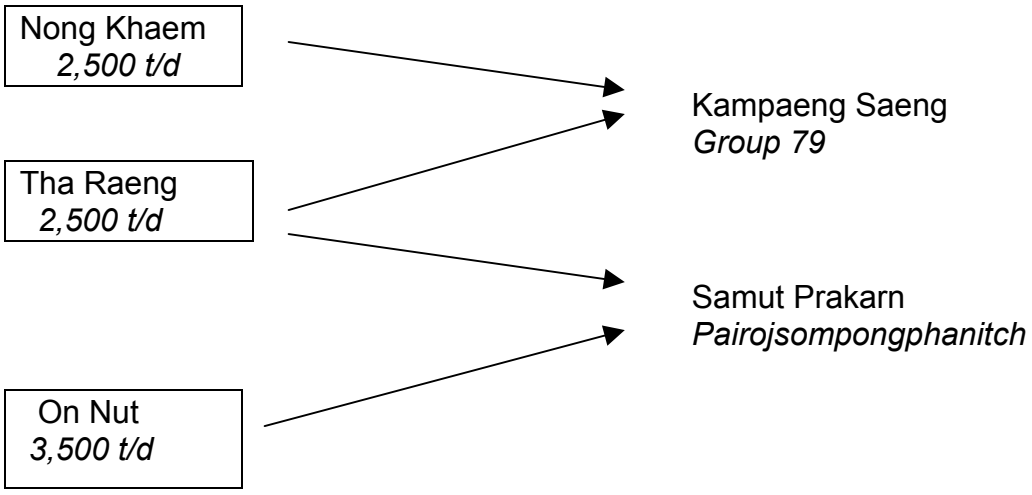
Waste is usually collected three times per week. Although higher numbers of waste bins could reduce the number of collection frequency, the hot humid climate is a haven for bacteria and therefore, accumulated garbage could be responsible for the propagation of smell, flies, rodents and associated diseases.

In the case of Bangkok, waste collectors are very interested in the selling of recyclable materials and therefore, collection frequency is higher while efficiency is lower. Waste collection trucks can often be seen on the side of the roads, stopped to allow waste collectors to open all the garbage bags and sort whatever recyclable materials can be recovered. The fact is that one truck of waste generates a total revenue of 2,000 baht (US$59), as supplemental income on top of the normal salary for those waste collectors working in the truck, including the driver. Therefore, the average number of trips per one truck per day can be estimated at 1.36.

4.3.4 TRANSFER STATIONS

In Bangkok, all waste collected is sent to three transfer stations located in the city: in the Eastern part of the city, (On Nut), in the West (Nong Khaem), and one in-between the two other transfer stations (Tha Raeng), as shown in Figure 13.

Figure 13 Landfill sites for Bangkok waste 2002



These facilitate the distribution of waste to the two landfill sites, and encourage on-site formal and non-formal sorting of recyclable materials. Each transfer station has a weighing scale to verify the tonnage entering and to be disposed. They also include a truck washing area and a sorting area where government employees along with local population sort waste, which is to be sold to wholesalers who in turn will sell to recycling companies.

Nong Khaem transfer station

Nong Khaem transfer station is built on 58.88 hectares of land located in a residential area east of the city center. In operation since 1991 as a transfer station, it used to house a compost plant, which was making 320 tonnes per day of compost using a digester drum, an incinerator for burning residues with a capacity of 10 tonnes per day, and a dumpsite, which was operational until the year 2000. The site also includes a nightsoil treatment plant with a maximum capacity of 600 m^3 per day with mechanical drying.

Over one million tonnes of waste was transferred to a landfill site located outside the city in Kampaeng Saeng at a cost of US$4.00 per tonne.

Nong Khaem transfer station currently receives 2,500 tonnes of MSW per day from the municipality, and pays US$ 10.26 per tonne for its disposal in Kampaeng Saeng.

Tha Raeng transfer station

Tha Raeng transfer station was built in 1992. It is the smallest of the three transfer stations and is built on an 8 hectares land within a residential area belonging to the government. The transfer station receives 2,500 tonnes per day of MSW from the municipality. MSW from Tha Raeng is sent to both Kampaeng Saeng and Ratchathewa landfill sites. The transfer station, although contained within a reinforced concrete wall, is surrounded by agricultural land with rice crops.

On Nut transfer station

The On Nut transfer station site is located on a site covering 93.28 hectares of land located in a residential area. This land belongs to the Thai Government and is located approximately 20 kilometers east of the city center. It receives an average of 3,500 tonnes of municipal solid waste each day.

In operation since 1969 as a landfill, it was converted into a transfer station in 1993. This site used to house a compost plant and an incinerator. The old incinerator was officially shut down in 1995, where it used to burn 280 tonnes per day of municipal solid waste. The compost plant, which used to treat 1,000 tonnes per day with a daily output of 300 tonnes of compost using fermentation digester drums, has also been shut down.

The site now has two hospital waste incinerators installed by the Australian company Scholer Incineration. They have been in operation since 1995 and destroy an average of 10 tonnes per day of hospital waste from the municipality. The site also receives 600 m3 of night soil, which is to be sundried prior to disposal.

4.3.5 HAZARDOUS WASTE DISPOSAL

Hazardous waste is separated, sorted and stored in a separate location on each of the transfer stations. The waste includes batteries, neon lights, aerosol cans, bleach bottles, residual paints and solvents. Once the storage area is full, the waste is transferred for stabilization in the industrial waste treatment facility.

4.4 FORMAL RECYCLING OPERATIONS

BMA has already established a preliminary sorting system using colored bins and encouraged people to use them appropriately.

Blue containers	For ordinary mixed waste and trash bags
Yellow containers	For recyclable waste such as plastics, glass and metals
Green containers	For organic waste from homes, schools, shops and fresh markets
Grey containers with red lid	For household hazardous waste such as fluorescent light tubes, light bulbs, batteries, insecticide cans and bleach bottles

Already in the year 1996, the Department of Public Cleansing made a press release announcing that each district should recycle at least 50 tonnes per day of waste by the year 2001. Considering that there are 50 districts within the BMA, this means that at least 2,500 tonnes per day of waste is being recycled.

Moreover, in 1997, BMA made a baht 50 million (US$1.5 million) advertising campaign towards the promotion of the use of the colored bins. Following verification of the efficiency of the bins, the system proved inefficient for the following reasons:

- There was an insufficient number of bins
- Some localities had only yellow and green bins and therefore household hazardous waste was found with other waste.
- Householders do not like to separate their waste and therefore just mix all the waste together indiscriminately.
- Since collection trucks do not have separate compartments, the usefulness of separating the waste at source appears to be senseless since all waste is mixed in the collection truck.

4.5 WASTE CHARACTERIZATION; A NECESSITY PRIOR TO DECISION-MAKING

Waste characterization is necessary to review the specificities of a country and its type of waste. This analysis allows the review of the quantity of waste, the quality of waste, its calorific value, hence an analysis, which gives good indications as to the type of treatment best suited and most feasible for the waste to be disposed.

Several methodologies have been developed for waste characterization, each one offering certain advantages and disadvantages. In the case of Thailand, the French Government designed MODECOM methodology was used. The MODECOM methodology was developed and registered by the Agency for Environment and Energy of France ADEME.

Waste characterization was conducted on two of the three transfer stations: On nut and Nong Khaem; one week was spent on each site. BMA gave access to all community inventories, data, collection charts, tonnage and any other information that was deemed necessary to ensure an accurate result of the characterization of the waste.

4.5.1 SCHEDULING AND BUDGETING WASTE CHARACTERIZATION

In order to be well prepared for the waste characterization, a specific schedule must be forecasted as to prepare the workers and the specialists. Moreover, a budget must be identified.

4.5.1.1 WASTE CHARACTERIZATION SCHEDULE

Preliminary investigation	1 – 2 days
Organization of the campaign	2 – 3 days
Sampling	0.5 day per sample
Sorting To be completed within 24 hours from receipt of waste	1 day of work per sample

4.5.1.2 FORECASTED EQUIPMENT AND PERSONNEL REQUIREMENTS

Preliminary investigation and organization of the campaign	Local authorities
Management and coordination	1 engineer
Bulldozer/mechanical shovel operator	One
Supervisor	1 technician

Personnel for sorting	6 laborers for sorting
Materials and equipment for taking sample from truck	- 1 x covered area where truck can empty load on concrete floor - 1 x weigh-bridge in vicinity - 1 x small mechanical shovel or bulldozer with bucket (dimension: 150 cm x 80 cm x 60 cm for volume 120 liters) - 1 x 60 kg weighing scale - Shovels - Brooms - Working overalls - Gloves - Masks - Calculator
For sorting samples taken from the tip-truck	- 1 x 2.5 m x 1 m sorting table with 100 mm circular mesh - 1 x 2.5 m x 1 m sorting table with 20 mm circular mesh - 1 x 2.5 m x 1 m recovering tray or sheet for residual materials - 25 x dust bins of 80 liter capacity - 1 x 60 kg weighing scale (accuracy to ± 10 g) - 100 l big bags - Rakes - 1 magnet (to verify metal content) - 1 – 2 lighters (to verify flammability) - Shovels - Brooms - Face masks - MSW - Working overalls - Protective gloves - 1 x safety kit
Laboratory analysis *Operating time: hours per sample*	1 x oven 1,000 l minimum capacity 1 x 4 kg weighing scale (accuracy ± 1g) *drying 24 hours to 48*

4.5.2 PREPARATION OF THE WASTE CHARACTERIZATION

In order to make an accurate waste characterization, several steps are required before the start of the analysis process, in preparation of the characterization exercise.

4.5.2.1 SELECTING THE SAMPLING PERIODS

Seasons may make a difference and therefore ideally sampling during several seasons should be made to offer a better picture of the local situation. In Bangkok, sampling was made upon request of BMA, and characterization was conducted only once, making it partially representative.

4.5.2.2 ACCURACY IN MEASUREMENTS AND THE NUMBER OF SAMPLES

Accuracy is increased when:

- Larger number of samples are analyzed
- MSW is heterogeneous
- A minimum of 5 samples are taken

The number of samples is determined by the objective of the sample. For example, to determine the general composition of the MSW, a few samples may be sufficient. To determine the composition of waste for each sector identified, at least 5 samples should be taken.

For large areas (>200,000 inhabitants) a minimum of 10 samples is recommended and therefore, 10 representative samples were collected in Bangkok.

4.5.2.3 SEPARATION OF THE ZONES TO BE STUDIED

The main objective is to select zones that offer greater homogeneity in a specific sector. The zone is defined as a group or sector to be studied. Zoning was selected according to concentration of populations and type of buildings. There are 50 districts in BMA and each district has specific zoning (commercial, residential, agricultural, and industrial)

Precise zoning for waste sampling is essential to ensure that the same area is not counted and sampled twice.

Figure 14 Map of Bangkok City with its 50 districts

Of Thailand's total population, approximately 10 million live in Bangkok. For the characterization, it was necessary to identify any events that may alter or influence the characteristics of the waste (i.e. fresh markets, tourism, special events or celebrations...)

The months of May until November are the Monsoon season. For the Bangkok study, waste characterization was conducted during the month of September during the Monsoon season. Humidity levels were therefore expected to be high.

The city of Bangkok can be divided into several sectors where waste characteristics vary. Therefore, in order to evaluate different household waste production, trucks collecting from different districts were selected.

4.5.2.4 SELECTION OF TRUCKS TO BE SAMPLED

Trucks were selected at random and truck drivers were not made aware that they were to be sampled in order to minimize any outside influence or changes in collection patterns as to ensure that it was representative.

Each sample was taken from the content of one truck from a minimum of five trucks per sample, selected and picked at random. Trucks coming from markets, industrial zones or other specific areas were not representative of the municipality's waste generation and therefore were not selected. Selection and sorting of one sample took one full day.

4.5.2.4.1 VERIFICATION OF TRUCK WEIGHT

A selected truck could not hold less than 2 tonnes of waste. If the weight was less than 2 tonnes, it was rejected. If the weight of the truck was more than 8 tonnes, half the truck was selected.

4.5.2.5 IDENTIFICATION OF CHARACTERIZATION AREA

Two areas were necessary to conduct the waste characterization: a sampling area and a sorting area.

Area 1. The receiving area

Area 1 was used to allow trucks to dump waste and to take samples of approximately 500 kg each.

This area had the following specifications:

- Area was covered in case of rain
- Area was close to weighing bridge
- Floor was made of concrete to enable collection of residuals
- Ceiling was high to allow easy access for the trucks
- Area was large enough to allow a front-loader to maneuver easily

Area 2. The sampling area

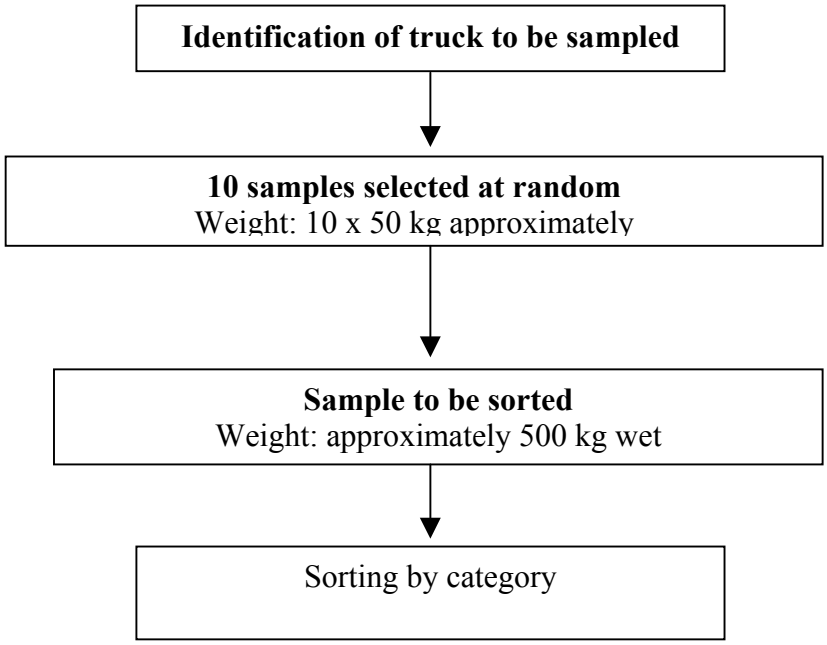
Area 2 was used to actually separate the various waste categories as to assess the percentage of each component category in the waste.

- Area was covered in case of rain
- Floor was made of concrete to enable the collection of fines
- Ceiling was high enough to allow easy access for trucks
- Area was large enough to allow a dozen people to work and to separate waste in various categories

4.5.2.6 THE SAMPLING

The objective was to randomly take 10 containers full from the truckload, using a mechanical shovel, each container holding approximately 50 kg.

Figure 15 Sampling procedure



There were 15 steps in the sampling operation:

1) Truck was selected (if a problem occurred, another truck from the same area was selected, a minimum of 5 trucks were used for one sample)

2) Truck was weighed on weigh bridge W1

3) Collection route was verified with driver

4) Atmospheric conditions were noted

5) Truck dumped its content in clean area (covered concrete floor) in area 1

6) Truck was weighed once emptied W2

7) Weight of waste (W) was calculated using W= W1 – W2 (kg)

8) Weight of MSW was calculated using weight of MSW (W) in kg and the number of fractions (NF) of 50 kg it represents: Nf = W/50

9) Ten numbers were drawn at random, chosen between one and Nf, for a total of 10 fractions. The total amount of these fractions made the total sample to be sorted.

10) The unit weight's preliminary sample was verified.

11) Sampling then started. The driver filled-up the bucket. The sample was marked as No.1. If it did not correspond to one of the drawn numbers, it was discarded as reject.
If it corresponded to one of the numbers drawn, it was placed in a specified area.

12) Operation was repeated until all of the area was emptied.

13) Residues (Y) remaining on the floor were collected with a broom and kept.

This operation did not require quartering; mixing was sufficient.

A proportion of residues (Y) equal to the sampling size was included into the sample.

$$Y = \frac{Z \times 10\, fractionssampled}{Nf}$$

Where:

Z = Weight of residues after sampling
Nf = total number of fractions of 50 kg approximately

14) Once sampling was complete, the 10 samples were placed in plastic bins capable of holding about 50 kg of waste, in preparation for sorting.

15) Sample was then tagged. Figure 16 shows an example of coding.

Figure 16 Example of coding on sorted samples

Code of community	Year of reference	Waste code	Order code
49000	2003	10	001

All codes remained the same except the Order code, which changed for each sample.

Note: All procedures and information were carefully written during the characterization.

- Identification of itinerary of collection truck
- The collection truck code
- The weight of the collection truck

- Meteorological conditions, especially the presence of rain during sampling
- Visual assessment of the waste
- Incidents that occurred during sampling

4.5.2.7 SORTING

The objective of sorting was to separate the different items or materials and place them in their respective category. Sorting was made following the ADEME sorting nomenclature of categories. In all, 12 categories plus Fines (thus 13 categories) was to be utilized in the sorting exercise.

Table 20 Sorting nomenclature of categories and subcategories used in France

Leaves and wood	Cut grass, flowers, leaves, small branches, etc.
Fruits, vegetables and food	Table scraps, fresh market waste, food waste, etc.
Paper and cardboard	Paper bags, wrapping paper, newspapers, magazines, boxes, corrugated boxes, egg cartons, etc.
Textiles	Wrapping fibers for fruits and vegetables, clothing, cloths, material bags, socks and stockings, etc.
Sanitary textiles	Disposable diapers, sanitary napkins, cotton swabs, paper tissues, household paper, etc.
Glass	Bottles, jars, lamp bulbs, etc.
Plastics	Film, plastics, PVC, polystyrene egg trays, milk bottles, plastic pipes, toys, etc.
Metals	Cans, aluminum foil, yogurt tops, pots and pans, copper wires, etc.
Unclassified Flammable	Wrapping cheese packs, fruit trays, egg boxes, etc.
Unclassified non-flammable	Rocks, gravel, potteries, shells, etc.
Composites	Wrapping made of paper, plastic, aluminum, tetra pack, coffee bags, etc.
Special waste	Batteries, aerosols, syringes, wrapping or materials containing paint, varnish or solvents, etc.
+ FINES	Residual waste following screening through 100 mm and 20 mm sieves

Sorting was conducted in Area 2 by six sorters, one responsible engineer, and one technical coordinator

Time required for sorting was half day per sample (one full day including selection).

Sorting had to be completed on the same day of its collection
Training was required prior to commencement of sorting to ensure that sorters understood each of the 13 categories, and final packaging.

Sorting was conducted in a roofed area on a clean concrete floor. Two sorting tables were fabricated; one with 100-mesh and another with 20-mesh holes.

Primary sorting: Pieces smaller than 100-mesh were separated and sorted into 13 categories.

Secondary sorting: Pieces smaller than 20-mesh were separated and sorted into 13 categories.

Figure 17 Waste characterization diagram primary sorting

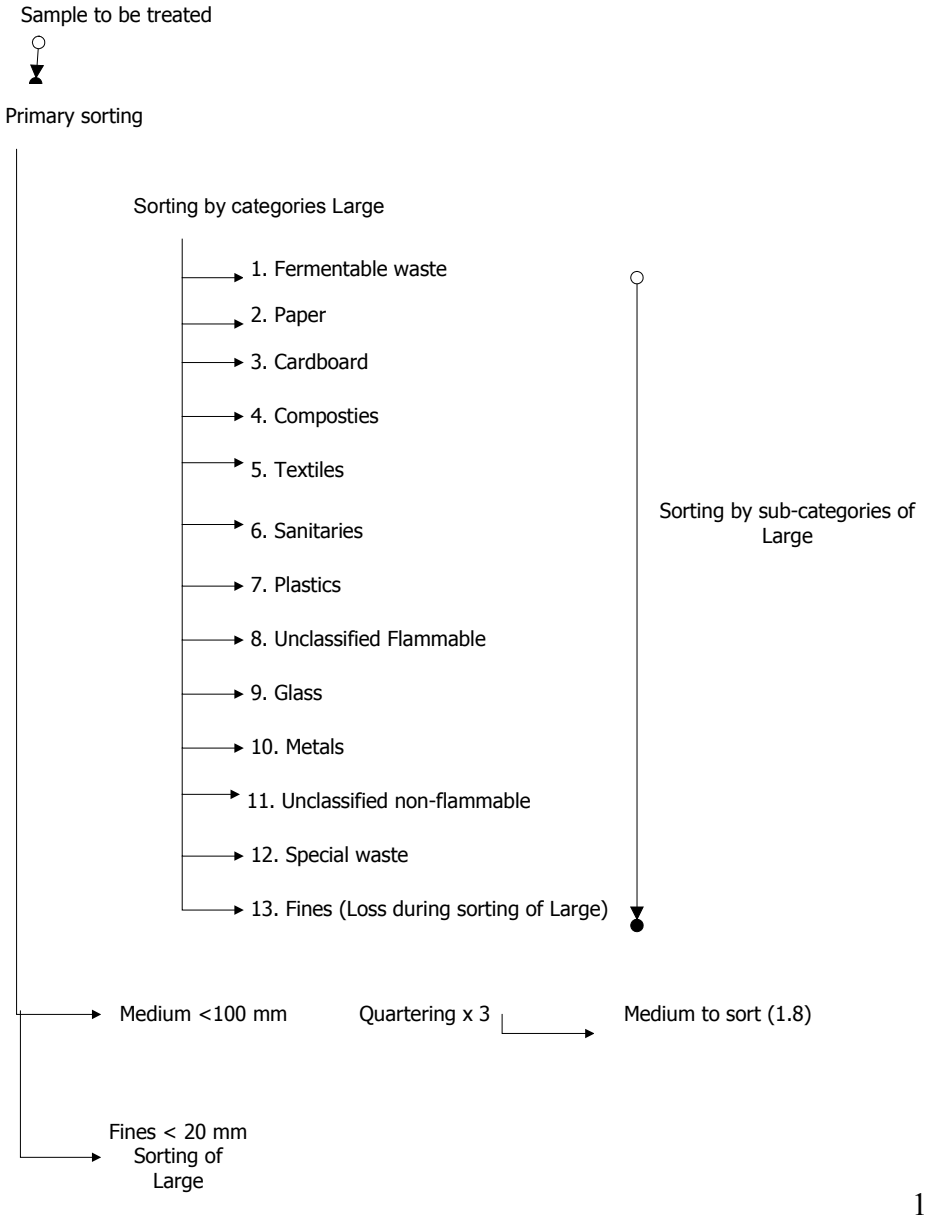
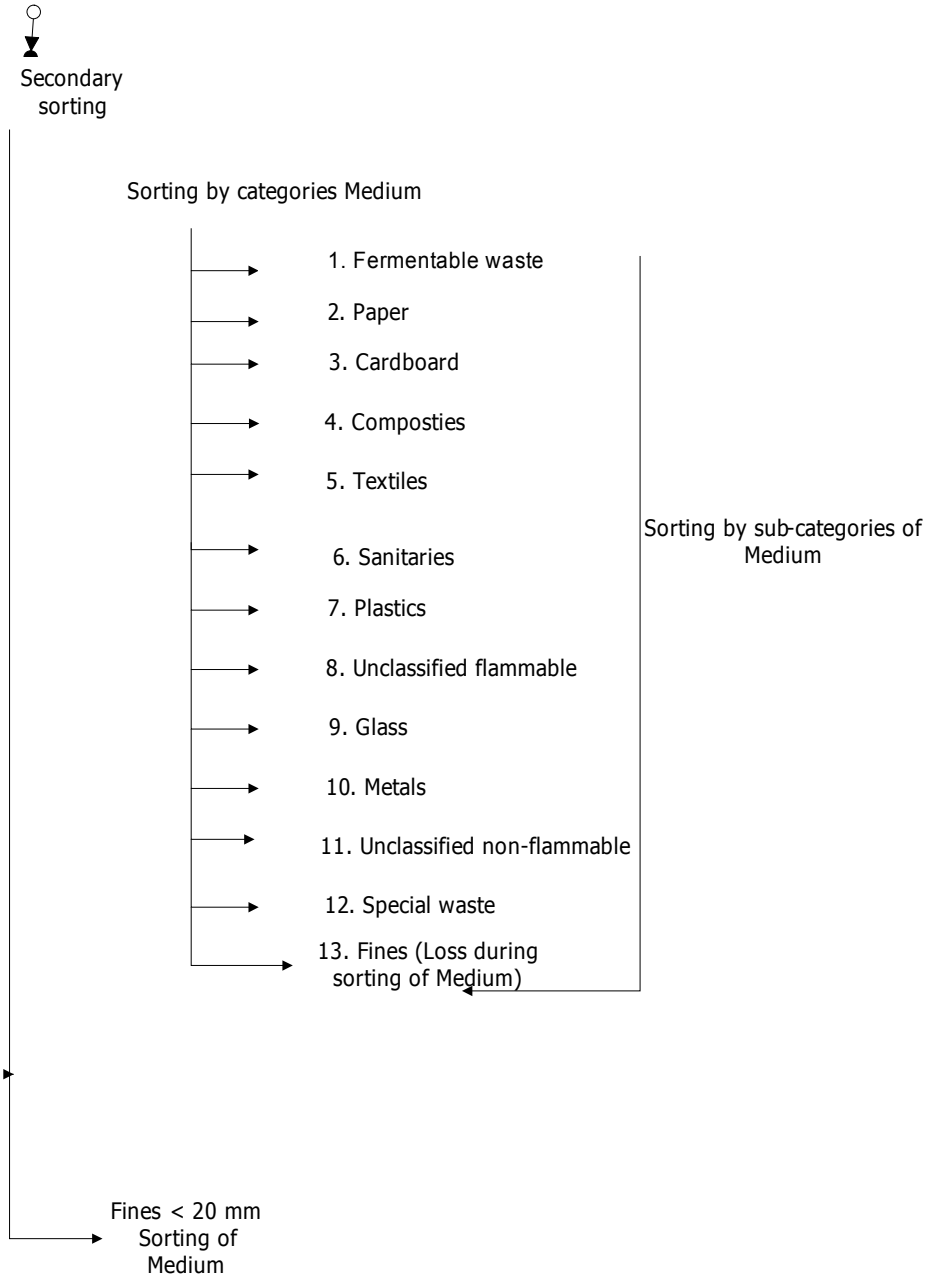


Figure 18 Waste characterization diagram secondary sorting



Small residual elements or those smaller than the 20 mm mesh were separated into on category namely Fines. Fines were recovered during primary and secondary sorting. All waste was sorted into the 13 categories.

A). Sorting in categories with two size segregation tables:

1. Each bin was weighed (W_1) and identified in order to know the initial weight, which was to be deducted from the total weight during the weighing.	
2. Bin contents were emptied in small quantity on the 100 mm mesh sorting table for size screening and determination of category L_1 (items larger than 100 mm) 3. Empty bins were weighed and subtracted from W_1, to obtain the exact weight of each sample bin.	
4. Large category materials were sorted by category into the 13-labeled bins. 5. Category bins containing large items L_1 were weighed	
6. Items that went through the 100 mm were collected and placed on the 20 mm sieve for separation of less than 20 mm items, and named mediums M_1. 7. Medium category materials were sorted by category into the 13-labeled bins. 8. Bins containing medium-sized items M_1 were also weighed.	

9. The Fines, namely all items that went through the 20 mm sieve were recovered and kept. 10. Fines were placed in bags and weighed.	
11. The 13 different bins of Large L_1 items were weighed 12. The 13 different bins of Medium M_1 items were weighed 13. Weight of the Fines was calculated during sorting of the Large and Medium.	
14. Category Large items were bagged, labeled and sent to laboratory for analysis. 15. Category Medium items were bagged, labeled and sent to laboratory for analysis	

Samples were not separated into sub categories, since it was not the objective of the waste characterization to have a breakdown of each of the categories.

Residuals were recovered and weighed following each sorting operation. They were included in the calculations. Weight of the losses was calculated and added respectively to those counted during the sorting of Large and Medium.

B) Verification of the coherence between collected values

Following each sorting operation, verification was conducted as to review the values obtained following the sorting of categories.

Sorting sheet

The sorting sheet includes all weighing operations made during the study:

- Total weight of sample
- Weight of Large sorted during primary sorting
- Total weight of the Medium
- Weight of quartered Medium
- Weight of Medium sorted during secondary sieving
- Losses obtained respectively during primary sieving and secondary sieving

4.5.2.8 ACCURACY OF THE RESULTS

Accuracy of the results is significant if the calculations are made with a minimum number of samples. The accuracy of the waste's characteristics certainly is higher with higher numbers of samples collected over several locations and during various seasons. Statistical interpretations must take into consideration the number of samples analyzed. Representative sampling not only takes into consideration the number of samples, but also location of samples and seasons for sampling.

4.5.2.9 RESULTS OF THE CHARACTERIZATION

Results of the laboratory analysis were calculated on dry weight of the total sample. To make the calculation, it was necessary to measure the humidity for each of the categories.

The composition of municipal waste collected in the study zone is determined, by its average. The composition is therefore expressed in % of humid weight.

The average composition for the category was the average of the results from sorting for the identified category.

The following tables show the results of waste characterization in the various locations for the ten collected samples, and for each of the identified categories.

Table 21 Results of waste characterization in Bangkok in kg on raw waste per category of large waste

Category of large waste	**Sample 1**	**Sample 2**	**Sample 3**	**Sample 4**	**Sample 5**	**Sample 6**	**Sample 7**	**Sample 8**	**Sample 9**	**Sample 10**	**Total**
	kg	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*
Leaves and wood	18.30	22.10	24.10	17.30	16.90	16.60	43.70	9.40	27.80	37.90	234.10
Fruits vegetables and food	9.90	53.30	17.90	56.50	54.80	16.20	45.40	41.00	58.40	41.40	394.80
Paper and cardboard	12.90	19.30	27.10	14.50	17.10	12.40	22.70	16.00	17.20	29.80	189.00
Textiles	3.90	14.90	19.90	7.40	14.30	15.80	2.20	11.80	9.50	9.20	108.90
Glass	8.10	3.50	12.70	15.10	6.10	6.40	4.70	7.00	10.00	10.40	84.00
Plastics	36.40	37.60	47.80	50.20	46.50	44.40	42.20	64.40	83.20	77.60	530.30
Metals	5.30	5.10	5.30	7.30	4.90	4.40	4.20	4.00	9.70	3.20	53.40
Unclassified Flammable	5.10	12.70	4.10	7.30	7.30	8.60	0.20	30.60	3.00	0.20	79.10
Unclassified non-flammable	0.40	2.30	1.30	1.90	2.50	3.60	2.10	1.20	6.60	3.40	25.30
Composites	0.60	0.90	1.50	1.50	0.90	0.00	0.00	1.00	1.10	1.00	8.50
Special waste	0.00	0.30	0.00	0.00	0.70	0.30	0.50	0.40	0.20	0.00	2.40
Sanitary textiles	1.90	3.90	3.90	2.30	5.50	10.40	3.20	1.40	5.70	7.20	45.40
Total Large (kg)	**102.80**	**175.90**	**165.60**	**181.30**	**177.50**	**139.10**	**171.10**	**188.20**	**232.40**	**221.30**	**1,755.20**

Table 22 Results of waste characterization in Bangkok in kg on raw waste per category of medium waste

Category of medium waste	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Total
	kg	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	*kg*	
Leaves and wood	7.20	7.20	6.20	3.40	3.40	5.80	34.30	2.00	2.60	2.20	74.30
Fruits vegetables and food	50.50	23.00	26.60	24.10	20.20	47.20	23.60	5.60	23.00	69.00	312.80
Paper and cardboard	6.40	3.80	5.90	5.50	4.70	6.20	2.00	4.60	4.40	2.20	45.70
Textiles	1.60	3.00	7.10	0.70	2.80	1.20	0.40	1.00	0.20	0.00	18.00
Glass	2.60	3.20	3.60	4.60	4.00	2.20	0.90	1.40	3.20	1.40	27.10
Plastics	14.30	8.60	9.00	9.90	8.00	23.80	5.70	9.20	15.00	14.00	117.50
Metals	2.00	1.40	1.50	1.30	1.50	1.00	0.80	0.80	1.20	0.60	12.10
Unclassified Flammable	0.00	1.80	0.80	0.00	1.10	0.00	0.00	13.60	0.00	0.10	17.40
Unclassified non-flammable	4.20	0.60	2.10	0.80	1.10	2.80	4.50	1.60	2.50	2.80	23.00
Composites	0.40	0.20	0.40	0.40	0.40	1.20	0.90	0.40	0.30	0.50	5.10
Special waste	0.60	0.40	0.00	0.40	0.20	0.20	0.20	0.00	0.00	0.40	2.40
Sanitary textiles	1.60	0.40	1.00	1.40	0.80	1.20	0.40	0.80	0.80	0.20	8.60
Total Medium (kg)	**91.40**	**53.60**	**64.20**	**52.50**	**48.20**	**92.80**	**73.70**	**41.00**	**53.20**	**93.40**	**664.00**
Fines	**53.30**	**36.00**	**49.40**	**39.00**	**36.00**	**49.00**	**43.60**	**43.80**	**24.80**	**55.20**	**430.10**

Table 23 Total waste characterized in % by wet weight and kg per category for Large and Medium waste

Total waste characterized	Total L+M	Total L+M
	%	*kg*
Leaves and wood	10.82	308.40
Fruits vegetables and food	24.83	707.60
Paper and cardboard	8.24	234.70
Textiles	4.45	126.90
Glass	3.90	111.10
Plastics	22.74	647.80
Metals	2.30	65.50
Unclassified Flammable	3.39	96.50
Unclassified non-flammable	1.70	48.30
Composites	0.48	13.60
Special waste	0.17	4.80
Sanitary textiles	1.90	54.00
Fines	15.09	430.10
TOTAL	100.00	2,849.30

Table 24 Results of waste characterization in Bangkok in % by wet weight of total samples per Large category

Category of Large waste	Sample 1 % by weight	Sample 2 % by weight	Sample 3 % by weight	Sample 4 % by weight	Sample 5 % by weight	Sample 6 % by weight	Sample 7 % by weight	Sample 8 % by weight	Sample 9 % by weight	Sample 10 % by weight	Average % by weight
Leaves and wood	17.80	12.50	14.50	9.50	9.50	11.90	25.50	5.00	12.00	17.10	13.53
Fruits vegetables and food	9.60	30.30	10.80	31.20	30.90	11.60	26.50	21.80	25.10	18.70	21.65
Paper and cardboard	12.50	11.00	16.40	8.10	9.60	8.90	13.30	8.50	7.40	13.50	10.92
Textiles	3.80	8.50	12.0	4.10	8.10	11.40	1.30	6.30	4.10	4.20	6.38
Glass	7.90	2.00	7.70	8.30	3.40	4.60	2.70	3.70	4.30	4.70	4.93
Plastics	35.40	21.40	28.90	27.70	26.20	31.90	24.70	34.20	35.80	35.10	30.13
Metals	5.20	2.90	3.20	4.00	2.80	3.20	2.50	2.10	4.20	1.40	3.15
Unclassified Flammable	5.00	7.20	2.50	4.00	4.10	6.20	0.10	16.30	1.30	0.10	4.68
Unclassified non-flammable	0.40	1.30	0.80	1.00	1.40	2.60	1.20	0.70	2.80	1.50	1.37
Composites	0.60	0.50	0.90	0.80	0.50	0.00	0.00	0.50	0.50	0.40	0.47
Special waste	0.00	0.20	0.00	0.00	0.40	0.20	0.30	0.20	0.10	0.00	0.14
Sanitary textiles	1.80	2.20	2.30	1.30	3.10	7.50	1.90	0.70	2.40	3.30	2.65
Total % Large wet weight	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 25 Results of waste characterization in Bangkok in % by wet weight of total samples per Medium category

Category of Medium waste	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Average
	% by weight	% by weight	% by weight	% by weight	% by weight	% by weight	% by weight	% by weight	% by weight	% by weight	% by weight
Leaves and wood	7.90	13.40	9.70	6.50	7.10	6.20	46.70	4.90	4.90	2.40	10.97
Fruits vegetables and food	55.20	42.90	41.40	45.90	41.90	50.90	32.00	13.70	43.20	73.90	44.10
Paper and cardboard	7.00	7.10	9.20	10.40	9.70	6.70	2.70	11.20	8.30	2.40	7.47
Textiles	1.80	5.60	11.10	1.30	5.80	1.30	0.50	2.40	0.40	0.00	3.02
Glass	2.80	6.00	5.60	8.80	8.30	2.40	1.20	3.40	6.00	1.50	4.60
Plastics	15.60	16.10	14.00	18.80	16.60	25.60	7.70	22.40	28.20	15.00	18.00
Metals	2.20	2.60	2.30	2.50	3.10	1.10	1.10	1.90	2.20	0.60	1.96
Unclassified Flammable	0.00	3.40	1.20	0.00	2.30	0.00	0.00	33.20	0.00	0.10	4.02
Unclassified non-flammable	4.60	1.10	3.30	1.50	2.30	3.00	6.10	3.90	4.70	3.00	3.35
Composites	0.40	0.40	0.60	0.80	0.80	1.30	1.20	1.00	0.60	0.50	0.76
Special waste	0.70	0.70	0.00	0.80	0.40	0.20	0.30	0.00	0.00	0.40	0.35
Sanitary textiles	1.80	0.70	1.60	2.70	1.70	1.30	0.50	2.00	1.50	0.20	1.40
Total % Medium wet weight	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Figure 19 Quantity of large size waste per sample

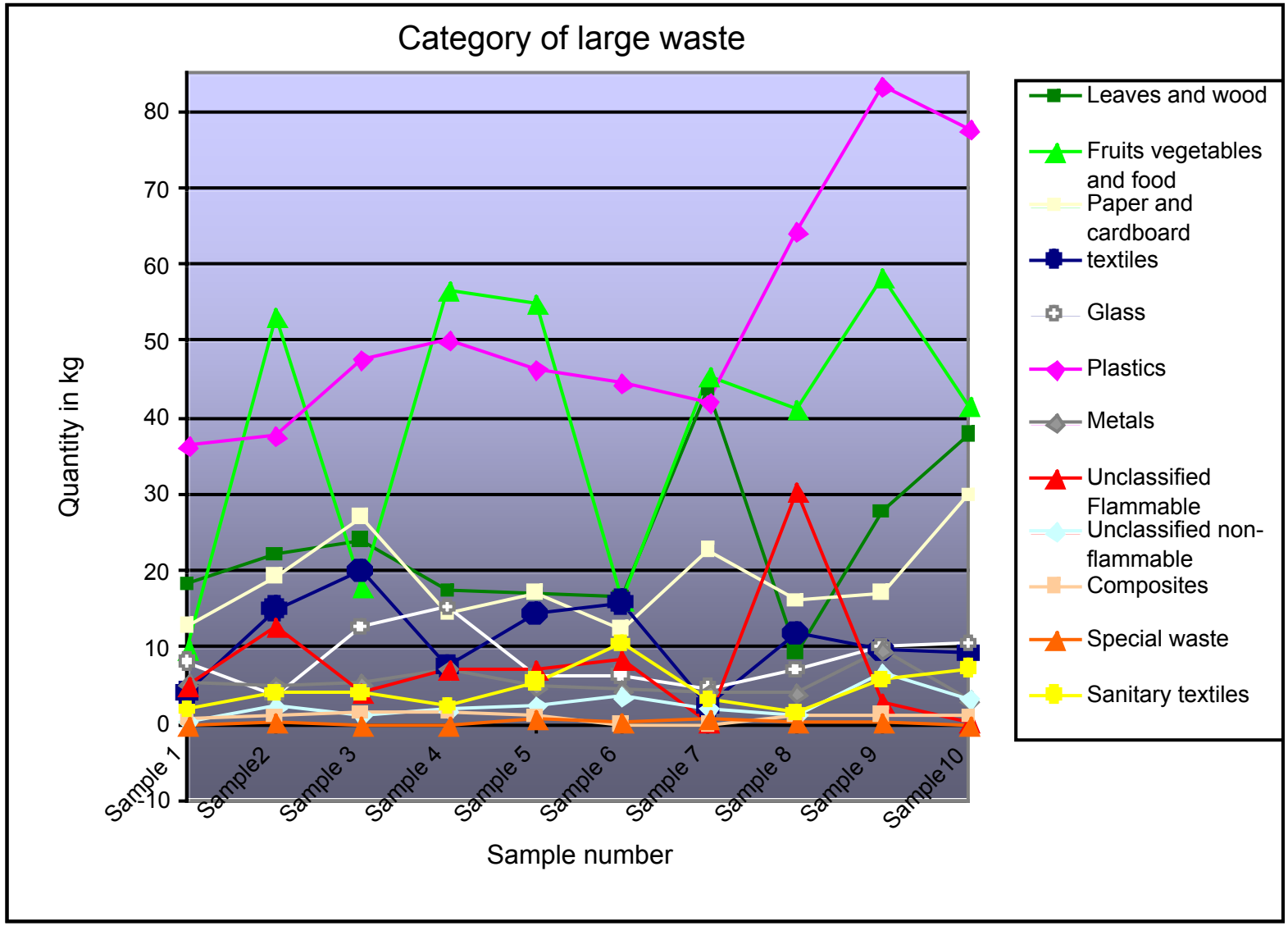


Figure 20 Quantity of medium size waste per sample

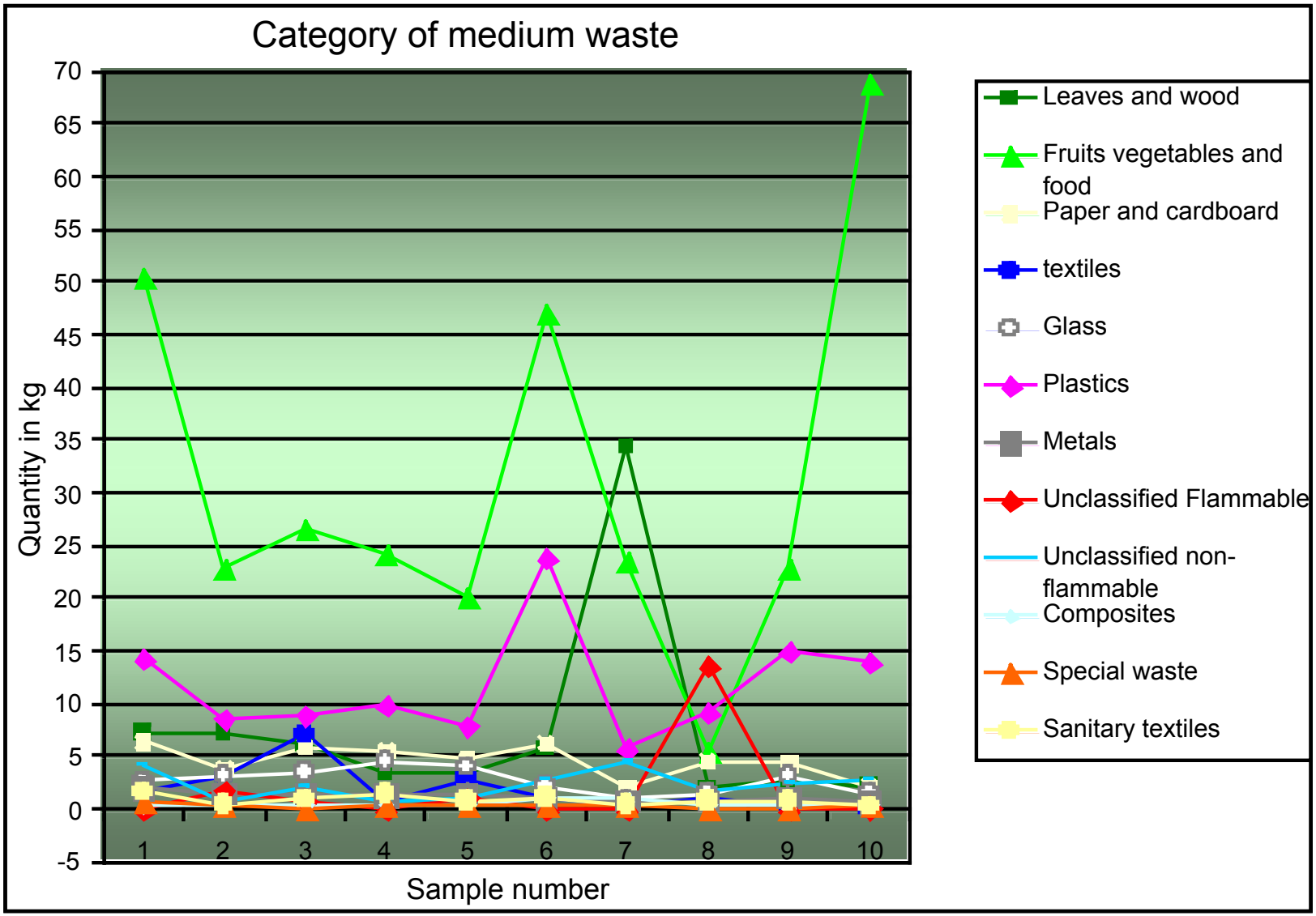


Figure 21 Waste composition for medium and for large size waste in % by wet weight

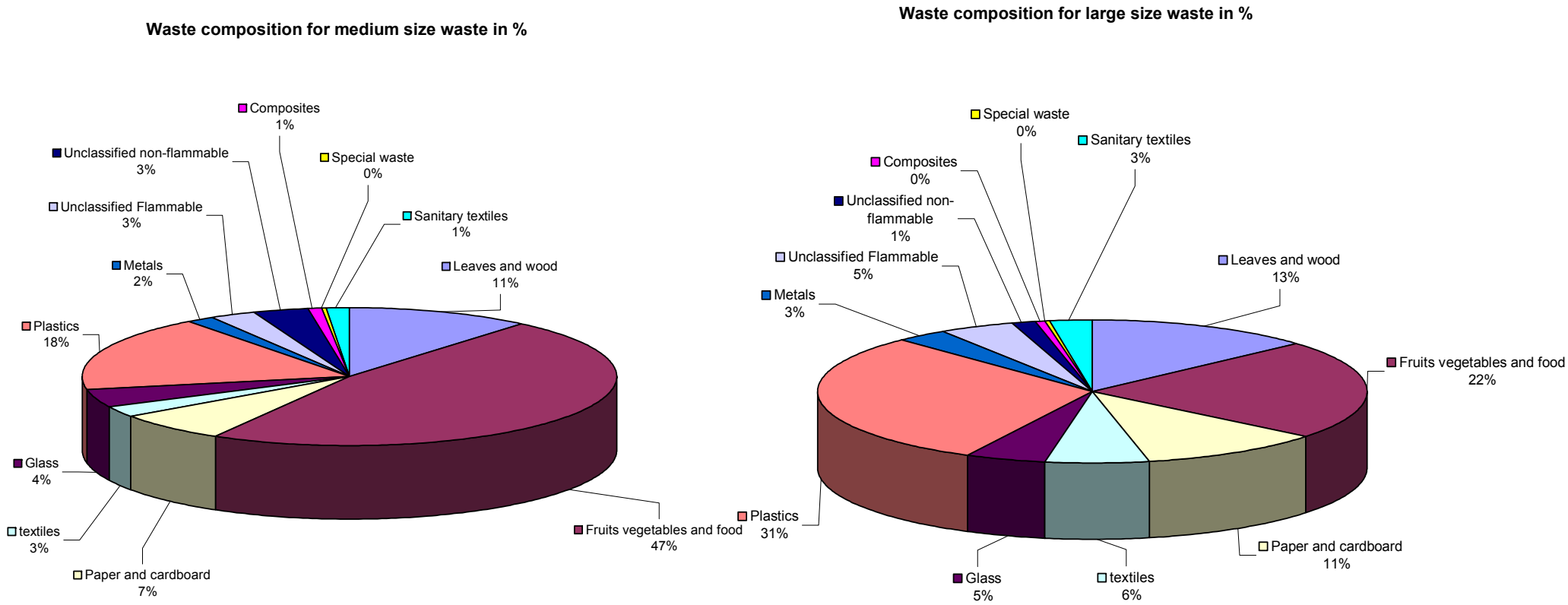
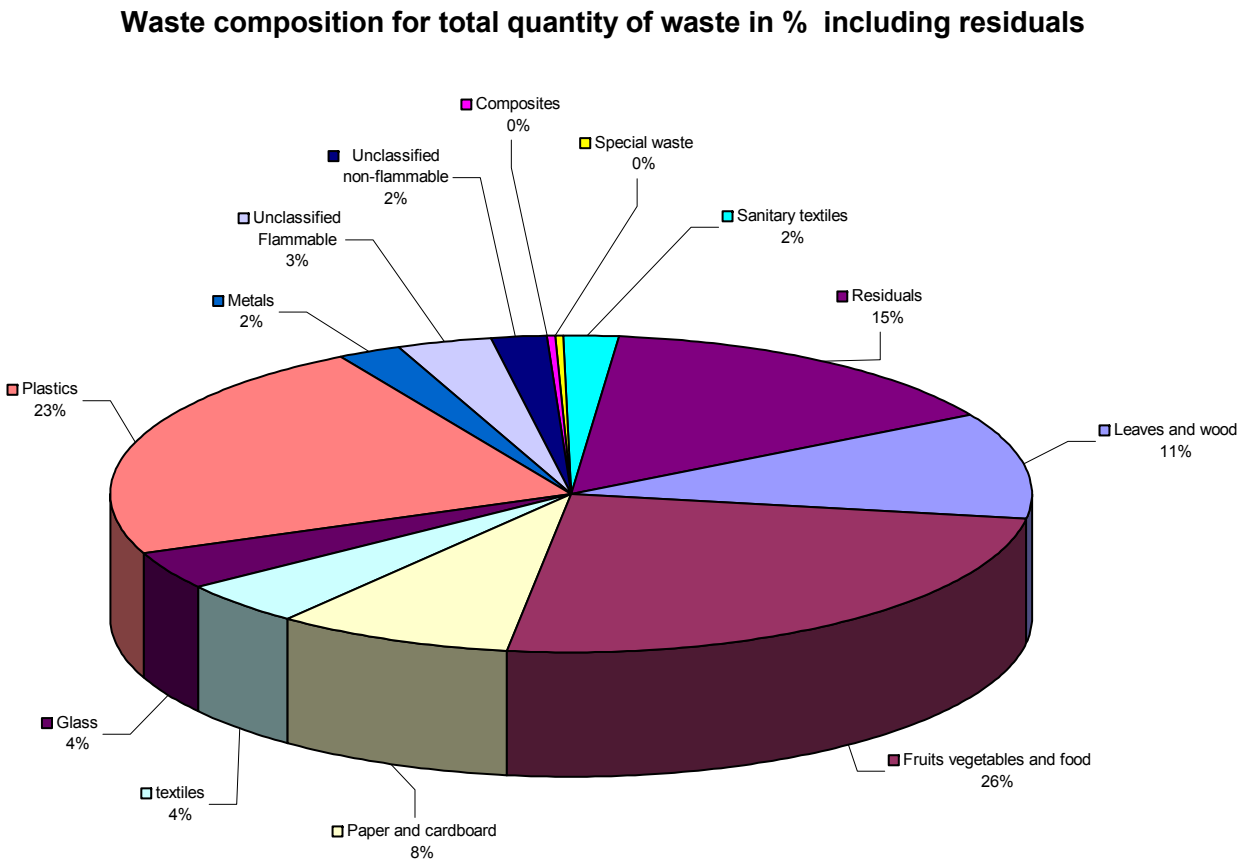


Figure 22 Waste composition for total quantity of waste in % by wet weight including residuals (fines)



4.5.3 LABORATORY ANALYSIS

Characterization was made by laboratory analysis on the different categories of the products collected during sampling. Analysis was made on the moisture content, volatile content, and low heat values as to determine the calorific value of the waste.

An accredited laboratory was selected. Each sample was clearly marked. The laboratory prepared the analysis powder for analysis.

Analysis procedures were in line with AFNOR, EPA, DIN standards.

4.5.3.1 SELECTION OF ANALYSIS TO BE CONDUCTED

The objective of waste characterization for the municipality of Bangkok was to identify the most feasible waste disposal solutions. Therefore, the verification of calorific value of the municipal waste for each category was of utmost importance.

Other interesting analyses that could have been performed include:

- Carbon and Hydrogen content by high temperature combustion
- Absorption of CO2 and water using appropriate reactive
- Nitrogen content using the Kjeldhal method
- Chlorine and sulfur content using combustion with a calorific bomb or high temperature
- Dosage of chlorine using specific electrode, using mercurimetry or potentiometry, for sulfur using gravimetry or colorimetry
- Heavy metals using spectrometry. Analysis methods should be standard to heavy metals analysis
- Total organic matter using calcinations at 500^{o}C or by oxidation

VOLUME TO SAMPLE AND ANALYZE

The volume or weight is directly proportional to the accuracy of the sorting and the heterogeneity of the pile. It was determined by calculating sampling variations on MSW.

To get an analysis variance comparable to the variance of the sample for 500 kg, the weights to be dried were specified for each category of municipal waste as defined in the MODECOM. These categories are:

Table 26 Categories of waste investigated

Categories	% of wet weight	Humidity in % of wet weight	Weight to be dried (in kg) for a 500 kg sample (defined in MODECOM)	Approximate volume Liters
Fermentable	7.10	72.40	10	50
Newspaper	6.40	37.80	4	50
Glossy paper	4.90	16.50	4	50
Cardboard	7.50	32.00	10	50
Composites	1.90	33.00	4	25
Textiles	1.70	37.40	4	25
Sanitary textiles	2.90	63.50	4	25
Polyethylene films	6.10	27.70	4	25
Other plastics	4.20	17.80	4	25
Combustible various	1.50	29.00	4	25
Glass	2.50	1.30	4	10
Metals	4.00	11.00	4	25
Non-combustible	0.30	6.00	2	5
Special waste	0.30	0.30	2	10
Fraction 20 – 100 mm	25.90	54.70	32	150
Fraction 8 – 20 mm	16.40	58.50	4	10
Fraction 5 – 8 mm	3.70	46.30	4	10
Fraction < 5 mm	2.70	32.00	4	10
Total	**100%**	**32%**	**108 kg**	**580 liters**

Source: ADEME, MODECOM Waste characterization methodology. P.55.

4.5.3.2 PREPARATION OF SAMPLES FOR ANALYSIS

Analysis procedures generally require the analysis of only a few grams. Therefore, the laboratory initially homogenized the product.

Each category was grinded in fine powder with a granulometry of < 500 micron. Contamination from the material used to prepare the powder was determined.

GRANULOMETRY OF THE POWDERS

Minimal rules to be respected in the making of powders were as follows:

- Reference material such as agate or carbonized tungsten had to be used
- Grinding materials had to be made of carburize tungsten, zirconium oxide, special metals dipped or others after verifications
- Stainless steel was eliminated

To treat the overall MSW, the first grinding material was capable of treating completely the wood, cardboards, polyethylene bags, bottles made of PVC, PET, PE, glass, rags, leather and shoes. Metals and batteries were pre-sorted.

Following the powdering operation, analysis was conducted: A new sample was prepared by mixing all powers for each category in equal proportion using the ponderable average of the municipal waste calculated.

PREPARATION OF SAMPLE POWDERS FOR LABORATORY ANALYSIS

Laboratory analysis on the calorific value and the heavy metals required a preparation of sampling powder with a granulometry of less than 500 micron-meters. During this preparation, it was necessary to keep in mind that contamination of the sample may occur, due to certain equipments such as grinders, during the preparation of the samples. Therefore, the laboratory took this into consideration and avoided contamination by using different grinders or receptacles, or by thoroughly decontaminating each item for each operation.

4.5.3.3 DETERMINATION OF HUMIDITY

Humidity determination was overseen by one laboratory technician. Materials used were, 1 retort of 1,000 liters minimum; 1 scale of 4 kg (accuracy 1 g)

Drying was done over a period of 24 to 48 hours per sample; measurements took one hour per sample.

Humidity was calculated by the drying at 105^{o}C (according to the French laboratory practices NF M03-002 standards which are equivalent to the ISO 589 / 579 and the ASTM D-2961 procedures for total moisture evaluation) of sorted materials.

The quantity considered for this determination corresponded to a weigh of approximately 110 kg (1/5 of the weight of the initial sample), a volume near 600 liters to dry. To this effect, the drying capacity in the laboratory was approximately 1,000 liters.

Humidity was determined on the categories sorted. In the Modecom methodology used, preparation of the measurement is made for each category.

1) Preparation of the trays necessary for drying in the retort was done by identifying them according to the references of the sample.

- Quantity of samples dried for each category: 2/3 for the Large collected during the primary sorting and 1/3 for Medium collected during the secondary sorting.
- Each sample was weighed
- Samples were dried
- Dried quantity was weighed
- Water content was calculate as a % of wet weight

4.5.3.4 RESULTS OF LABORATORY ANALYSIS

The following tables and figures show the results of analysis recorded following laboratory analysis. Table 27 shows the results of laboratory analysis for % of moisture content per category of waste. Table 28 shows the results from laboratory analysis for theoretical low heat value. Table 29 shows the results from laboratory analysis in % of volatile matter content for two selected categories. Figure 23 shows the humidity level per category in percentage. Figure 24 shows the calorific value of the waste. Figure 25 shows the volatile content by category of waste in percentage.

Table 27 Results of laboratory analysis for % of moisture content per category of waste

LABORATORY ANALYSIS REPORT

Total moisture by category in %	**Sample 1 %**	**Sample 2 %**	**Sample 3 %**	**Sample 4 %**	**Sample 5 %**	**Sample 6 %**	**Sample 7 %**	**Sample 8 %**	**Sample 9 %**	**Sample 10 %**	**Average %**
Leaves and wood	68.15	24.30	22.98	25.82	54.59	35.08	66.84	37.19	42.19	69.12	44.63
Fruits vegetables and food	40.75	39.89	41.88	58.61	62.06	34.54	60.96	67.33	72.51	78.64	55.72
Paper and cardboard	53.12	32.32	39.66	44.44	67.64	34.14	54.12	40.64	39.04	42.57	44.77
Textiles	46.37	17.34	23.33	11.78	38.15	18.73	27.22	29.34	18.71	50.97	28.19
Plastics	35.76	19.83	21.47	9.82	33.68	13.40	39.59	28.56	34.83	1.30	23.82
Unclassified Flammable	-	10.59	13.50	12.25	0.30	4.28	7.90	17.36	10.27	10.34	8.68
Composites	12.71	13.84	15.58	14.24	8.60	10.37	16.04	13.98	15.38	26.34	14.71
Sanitary textiles	52.20	14.32	15.00	15.83	32.47	6.24	32.40	33.06	54.80	60.30	31.66

Figure 23 Humidity per category in %

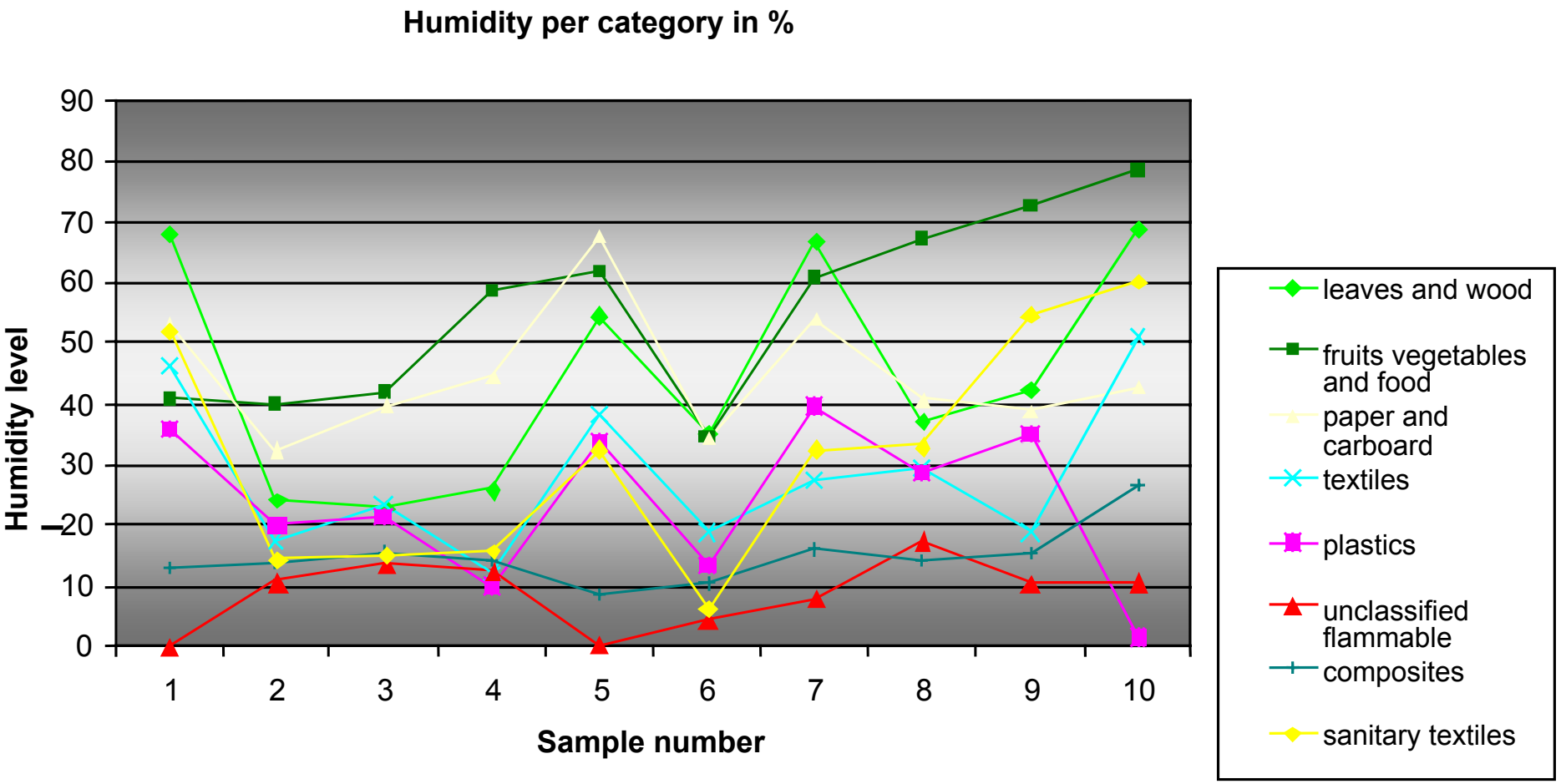


Table 28 Results from laboratory analysis for theoretical low heat value

District	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Average for all areas
LHV (MJ/kg)	9.50	13.00	12.30	11.50	8.80	14.70	6.60	12.70	9.30	9.40	11.86
LHV (kcal/kg)	2269.04	3105.00	2949.80	2746.73	2101.85	3511.04	1576.38	3033.35	2221.27	2245.15	2523.44
LHV (kWh/tonne)	2638.89	3611.11	3416.67	3194.45	2444.45	4083.34	1833.33	3527.78	2583.33	2611.11	3294.39

Figure 24 Calorific value of waste

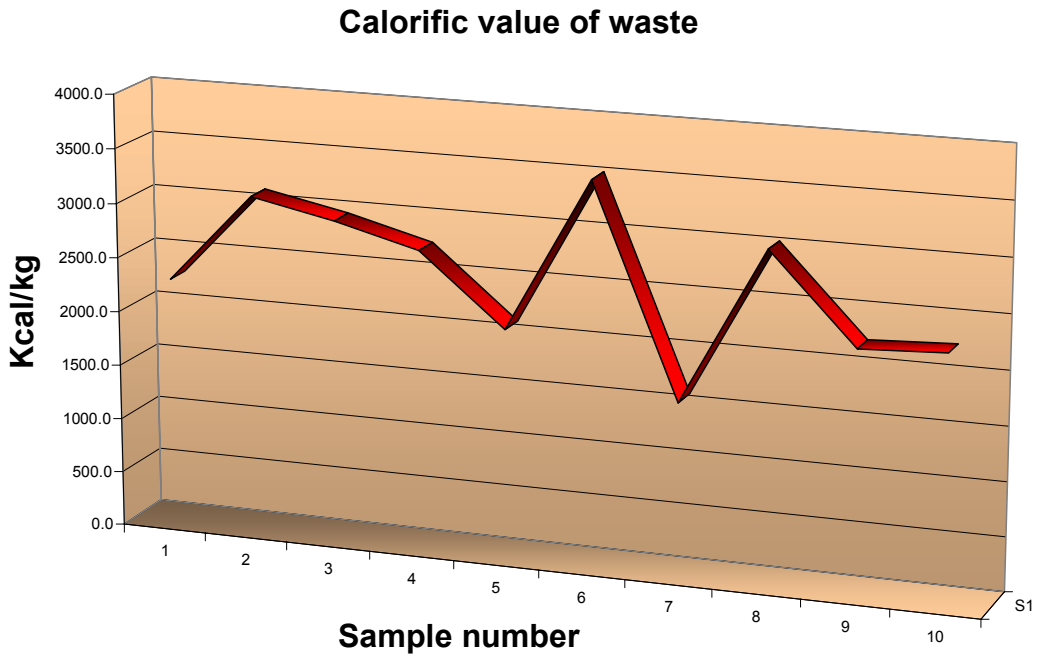
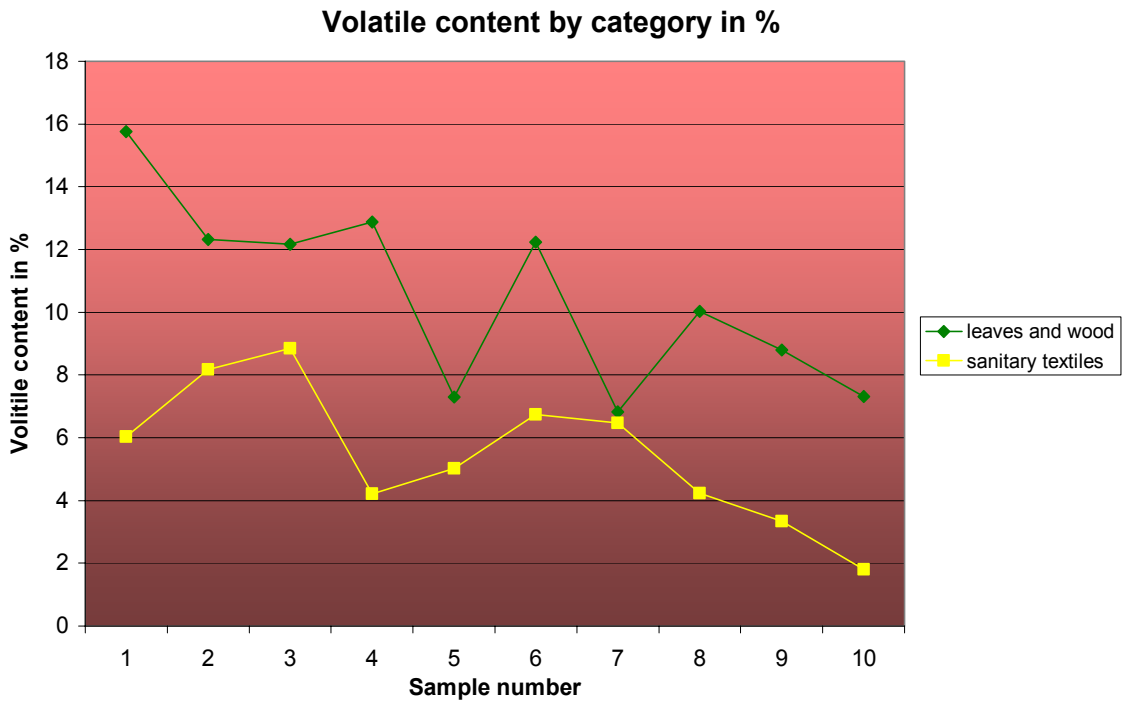


Table 29 Results of laboratory analysis for % of volatile matter content for two selected categories

Volatile by category in %	Sample 1 %	Sample 2 %	Sample 3 %	Sample 4 %	Sample 5 %	Sample 6 %	Sample 7 %	Sample 8 %	Sample 9 %	Sample 10 %	Average %
Leaves and wood	15.76	12.32	12.17	12.87	7.30	12.23	6.82	10.02	8.80	7.32	10.56
Sanitary textiles	6.04	8.18	8.84	4.21	5.02	6.75	6.48	4.23	3.34	1.80	5.49

Figure 25 Volatile content by category in %



4.6 LAWS AND REGULATIONS

Laws and regulations are crucial indicators as to the importance given to the management of MSW. Without the laws to force people to manage the waste properly, it is virtually impossible to manage MSW in a sustainable and adequate manner. In Thailand, it is the Public Health Act (PHA) of 1982 (Annex V), which oversees the management of MSW.

CHAPTER 3 of PHA (1982) Disposal of Sewage and Solid Waste

SECTION 18. Disposal of sewage and solid' waste in the area of any local government shall be the power and duty of such local government.

With reasonable cause, the local government may entrust any person with the task pursuant to paragraph one on its behalf under the- control and supervision of the local government or may permit any person to operate the disposal of sewage or solid waste under Section 19.

SECTION 19. Any person is forbidden to operate the business of collecting, transporting, or disposing of sewage or solid waste as a business or for payment of service charges, unless he has obtained a license from the local official.

SECTION 20. For the purpose of maintenance of cleanliness and establishment of orderliness in collecting, transporting, and disposing of sewage or solid waste the local government shall have powers to issue local provisions as follows:

(1) forbidding the discharging, emptying, leaving, or causing to exist in a public place or way of sewage or solid waste, except In the place provided by the local government for such purpose;

(2) prescribing that there be receptacles for sewage or solid waste available along public places or ways and private places;

(3) prescribing means of collecting, transporting disposing of sewage or solid waste or that owner or occupant of any building or place be required to practice correctly according to the hygiene and to the condition and nature of use of such building or place;

(4) prescribing rate of fees for services provide by the local government on collection and transportation of sewage of solid waste not exceeding that prescribed in the ministerial regulation;

(5) prescribing rule, procedure, and conditions on collecting, transporting, and disposing of sewage or solid waste, for observance by persons obtaining a license pursuant to Section 19, and prescribing a rate of maximum charges collectable by the persons obtaining a license pursuant to Section according to the nature of services provided.

(6) prescribing any other requirements necessary for hygienic practice.

MSW management is under the responsibility of local authorities. As such, the municipality of Bangkok, referred to as the Bangkok Metropolitan Administration (BMA), has the responsibility to manage the waste, and the authority to contract an independent company to collect and dispose of waste on its behalf. Special licenses are issued to the private sector for the management of MSW under the condition that rules, procedures and conditions are followed. Should there be a breach or non-conformity, such license can be suspended or revoked, with the possibility of revision by the Ministry of Public Health, which shall be deemed as final.

A collection and disposal fee can be charged but shall not exceed the rate of service fee prescribed by Ministerial Regulation No. 2, (1993), except in those cases where a private company is responsible for the collection and disposal of waste. Then and only then, may the fee exceed that which is proposed in the Ministerial Regulation.

Another Act, which oversees the management of MSW, is the Factory Act of 1992 (Annex VI). Although this Act mainly controls and regulates factories, Section 8 (5) also includes provisions for the management of MSW produced by the factory. As such,

factories are required to keep premises clean and free of garbage and refuse at all times. A Notification from the Ministry of Industry No. 1 B.E. 2541 (1998) was also issued pursuant to the Factory Act B.E. 2535(1992) regarding the disposal of wastes or unusable materials (Annex VII). Another Act is the Public Cleanliness and Orderliness Act (PCOA) of 1992, forbids activity that is likely to cause dirtiness to streets and public places.

The Enhancement and Conservation of National Environmental Quality Act (NEQA) of 1992 (Annex VIII) oversees all laws and regulations regarding the protection of the environment. A number of Ministerial regulations and notifications have also been published, in relation to existing laws and regulations. For example, the Ministerial Regulation # 9 was established to control the registration of private organizations who wish to engage in environmental activities in Thailand. This enterprise should not be politically driven and should be non-profit. The Notification of the Board of National Environment: # 20 (2000) Subject: Sub-terrain Water Quality Standard sets out quality standards of groundwater and sub-terrain as to control the presence of substances that can be hazardous or harmful for human consumption.

The Notification of the Ministry of Science, Technology and Environment, issued under the NEQA, and published in the Royal Gazette 7 August 1997 sets the standards of effluent of waste incinerators. Under this notification, the waste incinerator shall be divided into two sizes:

1. Incinerators with a capacity of more than one tonne per day or over but no more than 50 tonnes per day.

2. More than 50 tonnes per day

For the municipality of Bangkok, there is the BMA ordinance for Disposal of garbage, refuse and unclean things (1978).

The Pollution Control Department of the Ministry of Environment and Natural Resources published a manual entitled “Regulation and Guideline of Municipal Solid Waste Management (MSW)” in 1998. This publication reviews all criteria necessary for the building of a landfill site. All those built before 1998 are not subject to the regulations, as far as the on-going facilities are concerned. However, any expansion of the existing facility is subject to the laws and regulations. These describe:

- Siting criteria
- General requirements
- Design requirements
- Operation requirements
- Water quality monitoring requirements
- Closure procedures
- Long-term care
- Vertical expansion requirements.

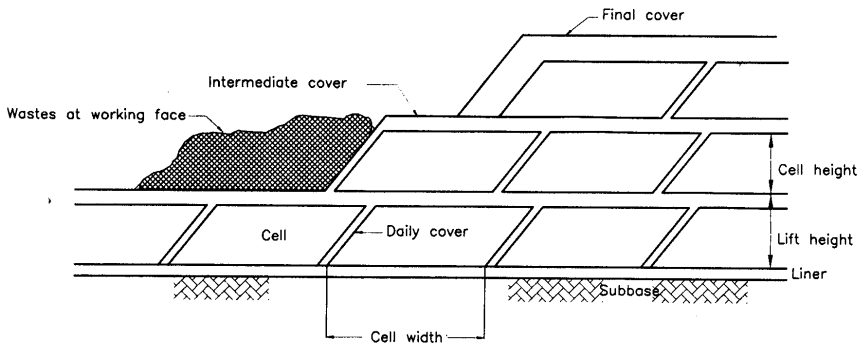
Thailand does not have three classes of landfills as they are known in the EC. Landfills in Thailand are classified into two classes:

Table 30 Landfill classification in Thailand

Class I	Landfills receiving general solid waste (MSW)
Class II	Landfills receiving non-putrescent waste such as plastic, rubber, wood, glass, construction and demolition waste, etc. (inert waste)

The regulation regarding the permeability of soil for the siting of a landfill is:

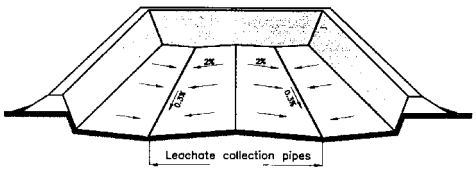
> $K \leq 1 \times 10^{-7}$ m/s with a minimum thickness of 3 meters. This must be extended laterally to at least 50 meters in all directions of the landfill site.
>
> The base of the landfill must be at least one meter above the groundwater table, unless special hydrostatic uplift control is provided.



Section of Compacted Waste Layers in Sanitary Landfill Unit

Lining of landfills

The guidelines propose several types of liner systems:
Low permeability: compacted clay K≤1 x 10^{-9} m/s and ≥ 0.6 m soil thickness

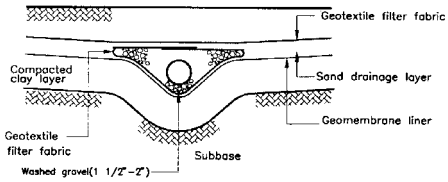


Leachate collection system

Single geosynthetic liner with low permeability soil: HDPE 1.5mm liner or similar, low permeability soil K≤1 x 10^{-7} m/s and ≥ 0.6 m soil thickness

Two composite liners are mentioned:

- Composite liner 1: HDPE 1.5 mm liner over compacted clay K≤1 x 10^{-9} m/s and ≥ 0.6 m soil thickness
- Composite liner 2: A true composite liner, which consists of a 1.5 mm HDPE geosynthetic membrane over a geosynthetic clay liner.



Detail of typical leachate collection pipe

Double liner: two 1.5 mm minimum thickness HDPE liners with a very permeable (k ≥1 x 10^{-1} m/s) drainage layer between the two liners.

Leachate collection and management

A leachate removal system must be installed above the liner. This consists of a 0.3 m thick granular drainage layer k ≥1 x 10^{-5} m/s and 100 mm minimum PVC or HDPE perforated pipe. The double liner system shall have a leachate collection system above the upper liner and between the two liners. The design of the leachate collection and removal system is such that it must never allow more the 0.3 m of leachate over the liner.

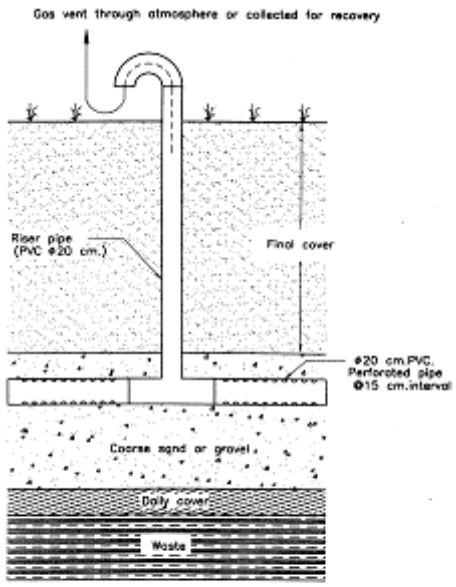
A leachate storage pond shall be constructed of either clay liner K≤ 10^{-9} m/s and thickness ≥0.6 m or a geosynthetic liner HDPE 1.5 mm minimum thickness and 0.6 m of compacted soil K ≤ 10^{-7} m/s. The storage pond can be built above or underground, with tanks coated to resist the effects of leachate. These tanks shall have secondary containments, and shall undergo regular inspections or continuous monitoring.

Discharged water shall meet the industrial effluent standards.

Landfill gas capture

In order to control the dangers associated with landfill gas, there must be control to prevent methane gas concentration:

- Levels of methane must not exceed the lower explosive limit (LEL) at or beyond the landfill boundary
- Levels of methane must not exceed 25% of the LEL (1.25% methane) in structures on or off-site
- Gases must not cause objectionable odors at or beyond the landfill boundary.



Typical detail of landfill gas collection system

Regulations allow two types of landfill gas control

- A passive system consisting of trenches or wells in which gas is vented to the atmosphere without pumping or treatment
- An active system in which the gas is collected using vertical wells, a piping network and vacuum pumps. The gas is then either converted to electricity or flared to meet air quality emission standards.

Storm water management

All storm water shall be collected and stored in a system designed for a 25 year and 24 hour storm event. Water discharged shall meet the Thai industrial effluent standards.

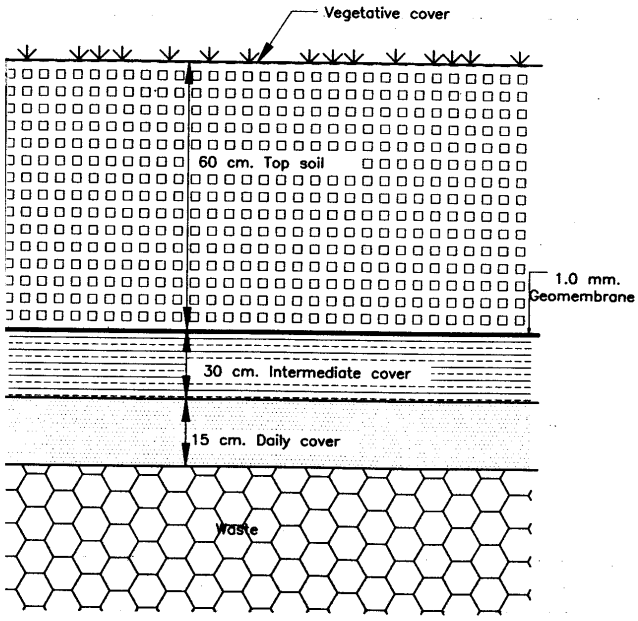
Landfill cover

Final slopes for land cover shall be steeper than 1:3 (vertical horizontal). Final covers differ according to the class of landfill.

For Class I.: The landfill cover shall not be more permeable than the bottom liner. In cases where the bottom liner is made of geosynthetic membrane, the final cover shall also be of geosynthetic membrane of at least 1 mm thick and shall be covered by a minimum of 0.6 m thickness protective soil layer for plant cover and erosion control.

In cases where there is no geosynthetic bottom liner, the final cover shall consist of a compacted clay layer, with a minimum thickness of 0.45 m and $K \leq 1 \times 10^{-9}$ m/s. This layer is then covered by a minimum protective layer of 0.45 m of soil for plant cover.

Class II. The landfill cover shall have a minimum thickness of 0.45 m low permeability soil layer with a maximum permeability of $K \leq 1 \times 10^{-7}$ m/s covered with at least 0.45 m of protective layer for plant cover.



Final cover for geosynthetic lining bottom

Size

The size of the landfill in Thailand is calculated based on a ratio of 620 rai (992,000m^2) per 500 tonnes per day of waste. Hence, if the landfill accepts 5,000 tonnes per day, the size of the landfill should be about 6,000 rai (9.6 million m^2) or 960 hectares.

Hydrogeological conditions

The Bangkok area is very close to the groundwater level and therefore, close to the first shallow aquifer. Luckily, this aquifer is rarely used because of surface water infiltration. Deeper aquifers however must be carefully protected and closely monitored. No wells should be closer than 700 meters from the limits of the landfill. The landfill should be built at least one meter above groundwater. A bottom liner should be installed with a minimum of 3 meters of clay soil with a maximum permeability of $K \leq 10^{-7}$ m/s.

Physical distances from landfill sites

Landfills must be located at a reasonable distance from sensitive natural and synthetic structures as to ensure environmental protection and potential nuisance. These distances have been established by the Thai Government as follows:

Table 31 Physical distance from landfill sites for various structures

Structure	Minimum distance from the structure
Waterways	300 m
Wells	700 m
Monuments	1 km
Airports	5 km

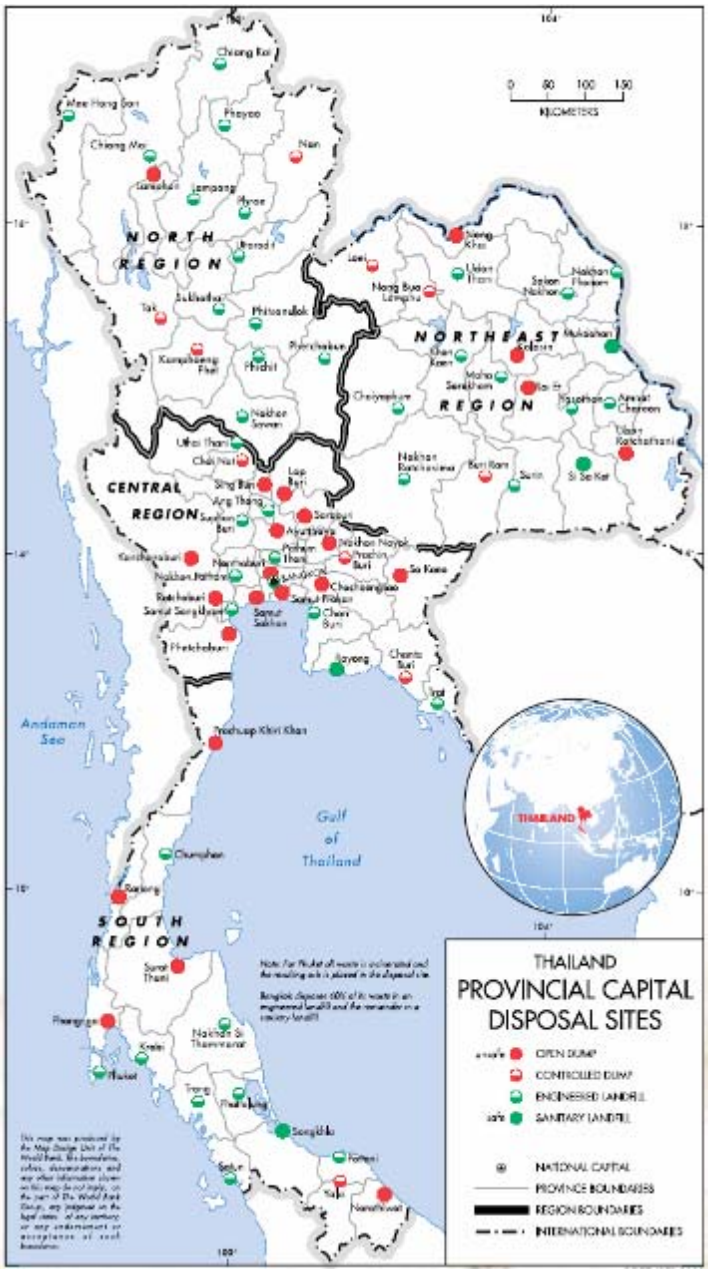
4.6.1 WASTE DISPOSAL IN THAILAND

Waste disposal in Thailand, as in many if not all developing and emerging countries, is not always the first priority of government. The need for infrastructure and social services is given priority. Then comes industrialization and once the pollution level has reached intolerable levels, the need for appropriate sanitation and waste treatment obliges the government to take immediate action and often-drastic measures to mitigate the problem of increasing population, of health hazard to the population and destruction of its environment. However, meanwhile, the need for treatment facilities required the population to organize itself in the disposal of its daily waste. This results in the appearance of a multitude of wild dumpsites in various parts of the country. This is true for many developing and emerging countries.

An example of this situation can be seen in Figure 26 where one can easily see that the number of open dumps far exceeds the number of controlled or engineered landfills. This is especially true in the center of the country, namely around Bangkok, which has the higher population density.

It is therefore necessary for governments to make early assessments, and take immediate measures to offer the population controlled sanitary landfills allowing people to dispose of their waste in a secure and environmentally friendly manner.

Figure 26 Waste disposal sites around Thailand



Source. Thailand Environment Monitor 2003

4.7 TREATMENT PLANT IMPLEMENTATION PROCEDURE IN THAILAND

Once the decision to set-up a waste treatment plant has been made, a lengthy sequence of events will be required prior to the new plant's start-up. The following gives an idea of the time required from the pre-feasibility review until the start-up and operation. This timeline will vary according to country, bureaucracy and political will.

Tasks	Approximate duration required for completion
PROJECT FEASIBILITY REVIEW	
Phase I Pre-feasibility study	**~ 2-4 months**
▪ Quantity of waste to be treated	
▪ Calorific values of waste	
▪ Capacity of waste treatment facility	
▪ Critical issues evaluation	
▪ Siting and assessment	
▪ Energy needs within the community or in proximity of the plant	
▪ Sale potential	
▪ Costs	
▪ Financing	
Phase II Political decision	**~ 3-4 months**
▪ Decision to investigate further	
▪ Decision to abort the project	
Phase III Feasibility study	**~ 3-6 months**
▪ Quantity of waste to be treated	
▪ Calorific values of waste	
▪ Capacity of waste treatment facility	
▪ Siting	
▪ Energy needs within the community or in proximity of the plant	
▪ Sale potential	
▪ Costs	
▪ Financing (sources, details)	
Phase IV Political Decision	**~ 4-6 months**
▪ Go ahead with project or stop	
▪ Establishment of priorities	
▪ Financing of plant	
▪ Review of logistics' implications	
PROJECT PREPARATION	
Phase V Set-up of organization and project team	**~ 6 months**
▪ Establishment of project organization	
▪ Set-up of institutional support	
▪ Institutional framework	
▪ Scheduling	
▪ Permitting	

Phase VI Tendering and financial preparation	**~ 3 months**
▪ Financial engineering	
▪ Negotiations of loans/grants/concessions/others	
▪ Selection of consulting firm	
Phase VII Preparation of tender documents	**~ 6 months**
▪ Reassessment of project	
▪ Specifications	
▪ Pre-qualification of contractors	
▪ Tender documents	
Phase VIII Political decision	**~ 3-6 months**
▪ Decision on financial package	
▪ Tender documents	
▪ Procedures	
▪ Final decision for project allocation	
PROJECT IMPLEMENTATION	
Phase IX Award of contract and negotiation	**~ 4 – 6 months**
▪ Short listing of contractor	
▪ Contract negotiation	
▪ Contract award	
Phase X Construction and supervision	**~ 16-24 months**
▪ Construction of plant	
▪ Supervision by independent consultant	
Phase XI Commissioning and start-up	**~ 6-10 months**
▪ Verification of plant parameters	
▪ Testing of plant performance	
▪ Settlements	
▪ Commissioning	
▪ Staff training	
▪ Start-up	
XII Operation and maintenance	**~ 10 – 20 years**
▪ Continuous operation	
▪ Maintenance of plant	
▪ Procurement of spare parts and supplies	

4.8 SOCIAL IMPACT AND IMPLICATIONS

The social impact of a MSW treatment plant is important in all countries. For Thailand, the social, socio-economic aspects are prominent. Communities must understand the implications and the importance of a waste treatment facility. The fact that it may be built within the vicinity of the community must be thoroughly discussed with community members. Such is the case in Thailand where public hearings have been held to discuss the issues involved in the construction and operation of a waste treatment plant.

Community awareness programmes are also key factors that help communities understand the process of waste management, and the various waste treatment alternatives such as recycling, waste to energy and waste transformation.

Markets such as industrial and even agricultural markets can be stimulated through the construction of a waste treatment plant. In Thailand, agriculture is still a prominent income generating activity and therefore, composting is often preferred. The level of skill of the local workforce will also be determinant. Thailand being an emerging country accounts for highly skilled labor. Yet, in general, the level of skill is average, mostly due to the lack of quality control.

An environmental impact assessment can also help identify, not only environmental issues, but also social and cultural issues.

Public participation through public hearings is compulsory in Thailand for all large projects. Although some systems and projects have been refused, no specific MSW treatment system has been banned. In fact, it is mostly due to lack of budget that treatment systems have been rejected. Experimental systems and trial systems are generally not acceptable in Bangkok, regardless of investment costs. In some instances, experimental systems were proposed free of charge to the municipality, and were rejected because of their unproven efficiency.

Health and safety issues are also crucial and it is the responsibility of the local government to ensure that the people in the community are protected from the health impact of the MSW. In Bangkok, waste pickers have been subject to contamination and explosions while working in non-formal waste recycling activities in the transfer stations and on the landfill sites. On the landfill sites, there were problems of explosions due to the accumulation of landfill gas. This situation has now been resolved with the installation of gas extraction and recovery in order to produce electricity.

There were also problems associated with the compost from the now closed compost plant. The compost was not matured enough and contained pathogens that were responsible for skin problems.

4.9 LIMITATIONS OF FINDINGS

In a country such as Bangkok, where humidity levels are as high as 100% with an annual average of 73%, the idea of waste management is automatically associated with high fermentation, high aerosols from the movements of liquids, high levels of bacteria and high humidity. This of course offers great advantage for composting which requires high humidity and heat. This in turn presents a serious challenge for incineration, which, in most cases, will require drying or additional fuel.

Public awareness shows that there are negative views on incineration, mostly due to ignorance based on experience associated with poor or non-existing air pollution control systems. The On Nut waste treatment plant used to have an incinerator, which emitted a lot of air pollution. The two incinerators for hospital waste are also polluting the air due to the poor management of the systems. With very high quantity of MSW such as in Bangkok where there is 9,000 tonnes of waste to be disposed of daily, incineration certainly offers an efficient way of reducing the volume of waste. Its feasibility needs to be studied on a case-by-case basis for each country. Bangkok has tried several times to build a large incineration plant. However, the costs associated with incineration are prohibitive for the local population, unless the incineration costs were to be partially subsidized by the government.

Findings reported in the dissertation conducted within the municipality of Bangkok are based on hands-on verification and information received by the municipality's administrators. It is assumed that all information provided is correct and for the majority, it has been verified in the field. However, some of the laws and regulations, and especially their implementations may be difficult to verify.

4.10 SECTION SUMMARY

Thailand has a total area of 513,125 km^2 and is divided into six topographical regions and 76 provinces. 9 million out of the 64.63 million people are living and working in the country's capital, Bangkok. A tropical country, Thailand's climate is hot and humid especially during its yearly monsoon season, with an average of 28.4^oC and an average humidity ranging from 70 to 100%.

The city produces approximately 9,000 metric tonnes per day of MSW. This includes a daily production of about one kilogram per person per day of household waste. Other types of waste produced on average include: 0.06 kg/per/day of industrial waste; 2.03 kg/bed per day of hospital waste; 0.49 kg/person/day of hotel waste; 0.49 kg/per/day of restaurant waste; 0.62 kg/m2/day of fresh market waste; 0.29 kg/person/day of school waste; 0.05 kg/person/day of shopping centers, offices and department stores. Seasonal differences in the quantity of waste must be taken into consideration when verifying the quantity and quality of waste.

Thailand has one of the best road and transport system in Asia, which facilitates communications and trade. Waste can therefore be handled properly giving accessibility to waste collection trucks around the country.

All waste collected in the municipality of Bangkok is transported to one of the three transfer stations before redistributing the waste to the two landfill sites. This collection is organized by specific schedules, and organized according to the type of housing, and by type of economic activities. Bangkok uses 2,400 collection vehicles to collect the waste from its 50 districts.

Hazardous waste is separated, sorted and stored in a separate location on each of the transfer stations. BMA has already established a preliminary sorting system using colored bins and encouraged people to use them appropriately. Moreover, waste is formally and informally sorted on trucks and at transfer stations. Sorters include civil servants and waste-pickers that need this income to survive on a daily basis.

In order to evaluate the waste, waste characterization was conducted. Waste was initially sorted into 13 categories. Waste was then sorted by size using a 100 mm sieve followed by a 20 mm sieve. Sampling was done at random on 10 containers, each container weighing approximately 50 kg, hence 500 kg of waste to be sorted. Trucks sampled were selected at random, without notification to the truck driver. Homogeneity is important as to give a representative sample. Therefore, specific zones were selected around the city of Bangkok. Samples were then sent to the laboratory for analysis on moisture content, calorific value and volatile content.

Laws and regulations are crucial indicators as to the importance given to the management of MSW. Without the laws to force people to manage the waste properly, it is virtually impossible to manage MSW in a sustainable and adequate manner. In Thailand, it is the Public Health Act (PHA) of 1982, which oversees the management of MSW.

5. Decision-making framework

5.1 DEVELOPING A DECISION-MAKING FRAMEWORK

With increasing decentralization, local governments are given the responsibility of managing MSW in an efficient and sustainable manner as to protect the health and well-being of their community members. To ensure successful implementation of their urban and environmental plan, they must promote environmental quality, sustainability, support of economic productivity and employment generation [Schübeler et al, 1996]. To maximize their success, they are encouraged to share their experiences and to build a network of city leaders [Hamid et al., 1999]. National policies should aim at waste minimization and as such, education and public awareness campaigns are required. One hundred percent collection of waste must also be ensured, as to include low-income and disadvantaged areas and ensure safety for the people and the environment.

A decision-making framework must therefore take into consideration the needs of the local community. Simultaneously, local communities have a responsibility towards community members and their environment.

Overall, local communities should:

- Encourage waste minimization through at source separation.
- Encourage recycling and re-use.
- Reduce avoidable waste (i.e. less packaging).
- Identify appropriate and sustainable waste disposal techniques.
- Maximize percentage of destruction and minimize residual waste.
- Ensure MSW and industrial waste management, treatment and disposal.
- Integrate environmental issues and urban planning.
- Minimize land use for proper disposal.
- Ensure minimal environmental impact during collection, treatment and disposal.
- Ensure appropriate MSW management, treatment and disposal either under governmental control or through a qualified and official contractor.
- Identify adequate financial resources.
- Prepare human resources for MSW management.
- Ensure cost-effectiveness of the MSW management plan.
- Identify environmental benefits.
- Support community participation.
- Ensure social acceptance.
- Review direct and indirect impacts of selected MSW plan on people and environment.
- Identify mitigation and alternative measures when needed.

- Strengthen government officers in the operation and management of MSW and its development plan.
- Review the advantages and disadvantages of privatization schemes.
- Prepare local government officials in better understanding project financing, contract management, monitoring and evaluation.
- Ensure full understanding of costs for municipal solid waste management.
- Maximize efficiency of MSW management.
- Know how to prepare a cash-flow for MSW management.
- Present financial implications to the citizens of the local community.
- Manage MSW disposal as a business.

5.2 IDENTIFICATION OF SPECIFIC OBJECTIVES AND PRIORITIES

The decision-making framework takes into account the specific objectives contemplated by decision-makers. The overall and most important objective is to allow decision-makers to choose the most appropriate system for the community. This can only be done based on the political will, community participation along with local legislation and their implementation. Because decision-makers are often not technicians and generally not specialized in environmental engineering, the decision must be driven by factors that are known and well understood by decision-makers. These decision-makers must be persuaded to bring their community to the 21st century by installing comprehensive MSWM systems that comply with international standards, which will protect the local population and the environment. Protecting the environment will further protect the country's natural resources, which are crucial to its development and a source of income for the population.

In view of the humidity existing in tropical countries, all equipment must be tropicalized and customized for tropical countries, and well adapted to handle high temperatures and wet waste especially during the rainy season. As an international trend, and towards waste minimization, decision-makers are encouraged to use environmentally friendly technologies and to promote recycling and composting as to transform waste into valuable products. This is especially viable for low-income countries, creating employment opportunities to families, local populations, and disadvantaged groups living near or on the waste sites. Moreover, low labor costs allow the minimization of operation and maintenance costs for installed equipment.

With high population growth, land utilization must be optimized. This especially applies to Asian countries where population density is an issue. Therefore, plant footprints are important factors when selecting a treatment plant. Landfill sites are becoming more difficult because of the space requirement and the often little availability of land in proximity of the community especially in Asian countries. Integrated systems minimizing the quantity of waste to be disposed in the landfill becomes a logical option. Moreover, the reduction or elimination of organic waste sent to the landfill site will not only minimize the quantity of waste to be disposed, but will also help reduce the greenhouse gas production associated with landfill gas.

Experience sharing among municipalities can often be helpful in understanding the problems and avoiding them. The appropriate system will not only improve the quality of life of the local population and its environment, but will also encourage tourism while improving the quality of agricultural products sold locally and those exported.

5.3 DEVELOPING THE DECISION-MAKING FRAMEWORK

The overall procedure used for the development of the decision-making framework, can be summarized as to:

1. Identify the objectives and the key aspects that can influence decision-making for MSW management

2. List the number of elements involved in each of the aspects against which the results and options should be assessed and compared

3. Identify a list of alternative integrated waste management options that are recognized as appropriate systems and that can be used towards the attainment of the targeted objectives of a local community.

4. Determine the values of acceptability and non-acceptability for each element

5. Eliminate all options that are considered unacceptable prior to further analysis whether because of legal compliance, financial constraints or social unacceptance.

6. Review the number of elements for each aspect

7. Construct the hierarchy of the aspects and their elements as to verify the sensitivity of the scores to changes in the assumptions made

8. Prepare closed questions with multiple choices for information gathering and data entry.

9. Associate elements that can be compared as to facilitate the decision process

10. Make a final decision on a feasible integrated MSW management system by using an objective and transparent tool

5.4 GATHERING OF NECESSARY DATA

In order to gather the necessary data and to ensure the right answer is given, careful preparation of questions and redundancy of certain questions as a verification mechanism and for weighting of key elements was necessary. Therefore, a detailed questionnaire was prepared that allows the decision-maker to review the information in hand, and to gather all information necessary for making the appropriate decision, based on facts and not on political or social influence. However, the political and social pressures must be taken into consideration when making a decision on the type of treatment that should be selected for a municipality. Questions must be asked to the right persons as to ensure the correct answer. Because the decision-making tool is to be used

by the decision-makers themselves, the accuracy of the answers will depend on the honesty and willingness to find the appropriate solution for decision-makers. Biased information and false statements will only damage the end-result of the analysis, rendering the tool useless. The gathering of preliminary data is done through specific, closed ended questions. The accuracy of the results will therefore depend on the exactness and truthfulness of the answers.

5.5 SPECIFICATION OF DECISION-MAKING ISSUES

Decision-making issues used in the framework are selected areas of concerns, which need to be taken into consideration before selecting a feasible and appropriate waste treatment system for the community.

5.5.1 THE ISSUES ADDRESSED IN THIS FRAMEWORK ARE:

1. GENERAL DESCRIPTION
2. CLIMATIC AND HYDROGEOLOGICAL CONDITIONS
3. WASTE PRODUCTION AND CHARACTERIZATION
4. EXISTING FACILITIES REVIEW
5. COMMUNITY AWARENESS PROGRAMMES
6. SOCIO-ECONOMIC IMPACT
7. PUBLIC PARTICIPATION
8. ENVIRONMENTAL CONCERNS
9. HEALTH AND SAFETY CONSIDERATIONS
10. DISPOSAL OPTIONS
11. SYSTEM COSTING

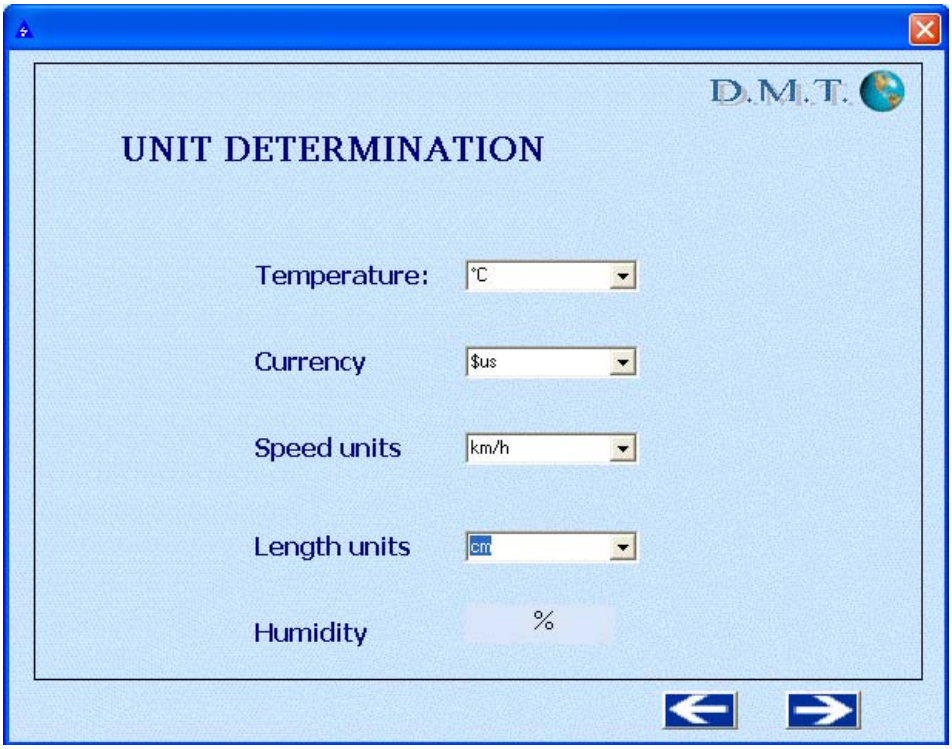
Each of the issues addressed were broken into specific and closed questions. This allows municipal administrators to answer, as objectively as possible, without the need for interpretation, whether on the part of the question or on the part of the provided information. As such, questions include multiple choices and specific data compilation, limiting the possibilities of personal interpretation.

All questions were processed in an easy to use Decision Making Tool, offering a fast and simple preliminary analysis of the various options given to public administrators.

The following are the frames developed for the decision making tool, showing the questions that need to be answered, and addressing the specific issues necessary in the decision-making process:

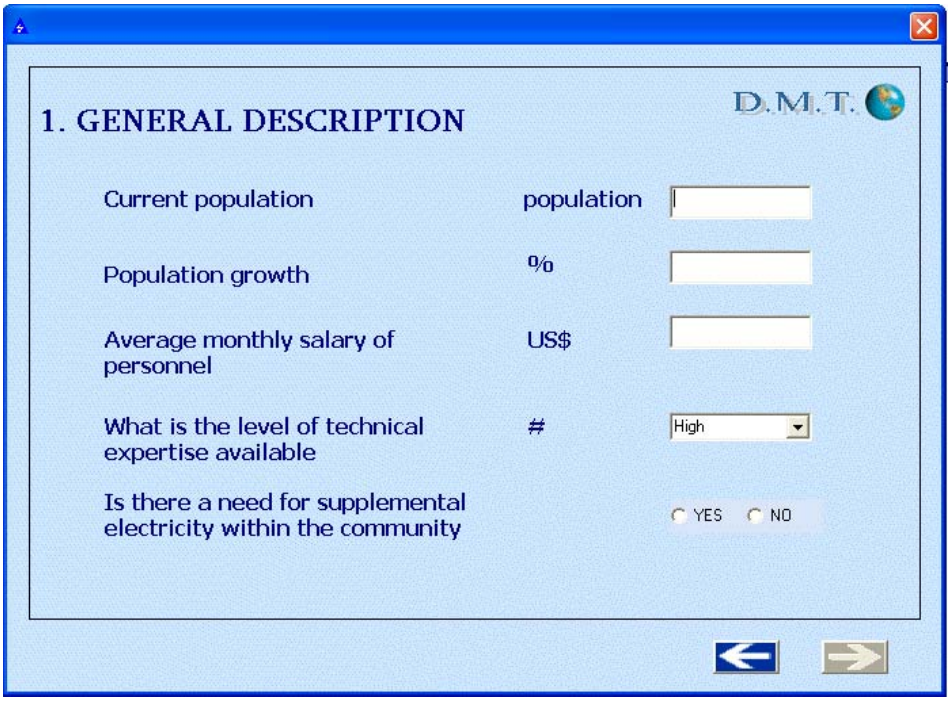
Title frame. Title frame introducing the decision making tool

Unit determination Frame. The second frame gives the unit determination, which is to be used all along the questionnaire. These are necessary as to ensure that the right values are inserted.



Frame 1. GENERAL DESCRIPTION

This preliminary issue is to provide general and basic information on the municipality.



- **Current population**: The current population is necessary to evaluate the type of system that can be used. In fact, a combination of systems is often preferred, especially for large populations. These can be evaluated in the data analysis part.

- **Population growth**: The growth of population is also important in the selection of a system. When population growth is very high, the flexibility of the system becomes even more necessary.

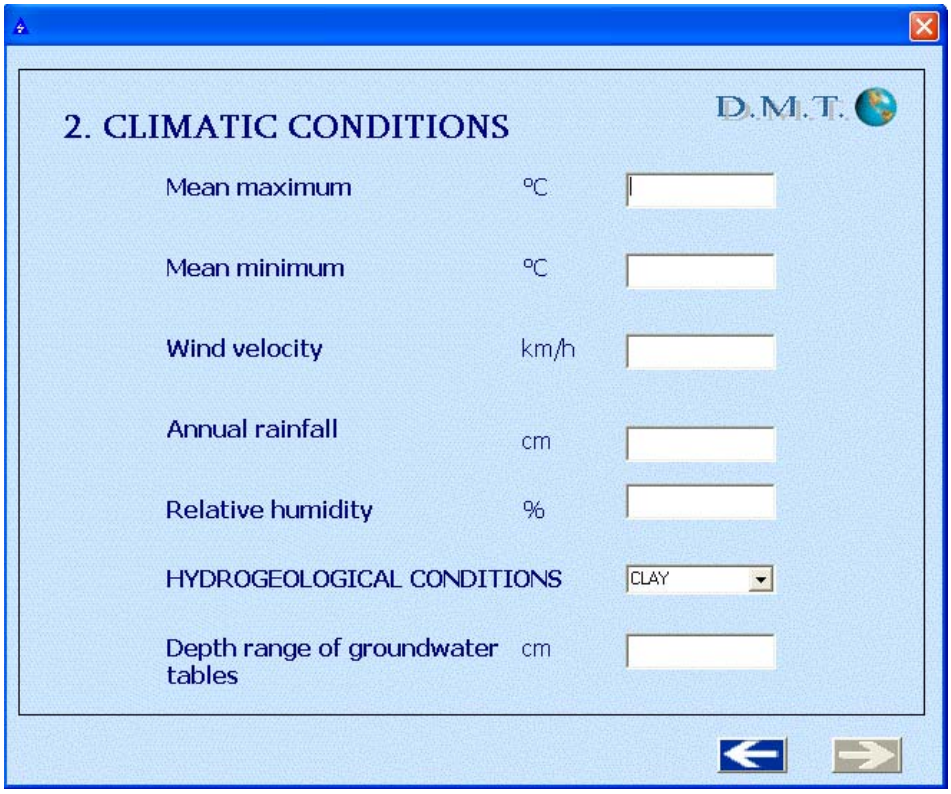
- **Average monthly salary of personnel**: High labor costs usually associate with higher mechanization while lower salaries allow more labor intensive systems.

- **What is the level of technical expertise available**: The complexity of the operation and maintenance can be determined by the availability of local technical expertise. Especially in developing countries where technical expertise is low, the selected system must allow minimum maintenance and operational complexity. A more manually operated system is often preferable.

- **Is there a need for supplemental electricity within the community:** The shortage of electricity in developing countries is a frequent situation. Therefore, although waste to energy systems may be more costly, they may be useful contributors to a community's development by supplying the required energy.

Frame 2 CLIMATIC / HYDROGEOLOGICAL CONDITIONS

Climatic and hydrogeological conditions are determinant in the verification of humidity and heat, which are key factors in the condition of waste to be treated. Moreover, this section looks at hydrological conditions in order to verify the depth of groundwater tables, which need to be protected.



- **Maximum temperatures**: Temperatures play a key role in the evaporation and in the proliferation of bacteria, viruses and the existence of pests and rodents. Moreover, the rate of degradation and the production of NH_4 associated with the biodegradation of organic waste make temperature an important factor in waste management.

- **Minimum temperatures**: Minimum temperatures are also determinant since in some areas, the freezing temperatures (namely at high altitudes), make biodegradation a timely event. This, for example, may jeopardize or slow down the process of the aerobic composting.

- **Wind velocity**: Wind is associated with the spread of aerosols found in wastewater and landfill leachate. It is also a contributing factor to evaporation. More importantly, it can be used as a potential source of energy in the use of eolians for the production of alternative energy.

- **Annual rainfall**: The quantity of rain is relevant to the level of humidity. It is also necessary to prepare protection for the waste against rain when rain levels are high, as to avoid the quantity of water and leachate produced and to be treated.

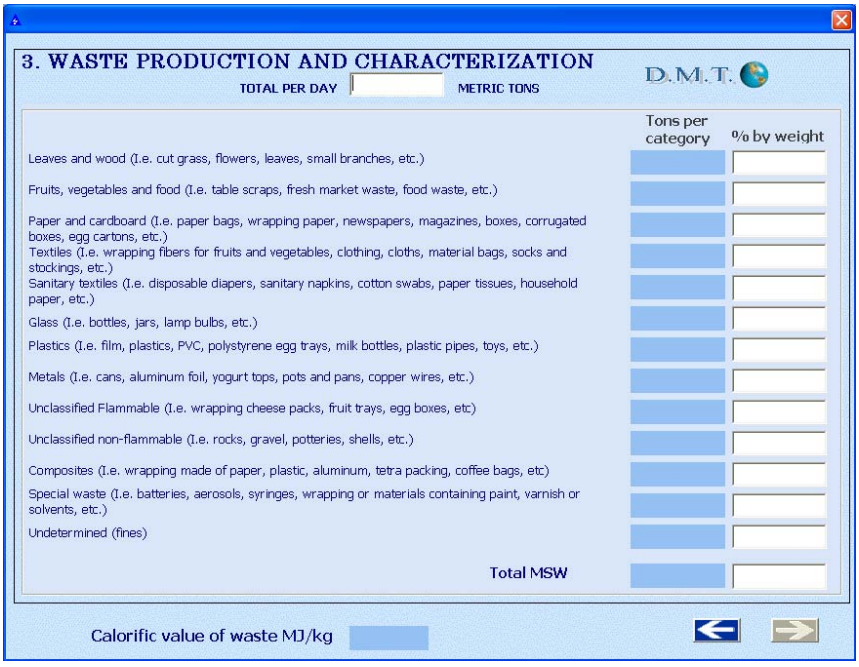
- **Relative humidity**: The level of humidity has a direct impact on the multiplication and proliferation of bacteria and viruses, and on the speed of degradation of the waste.

- **Hydrogeological conditions**:
    - **Type of soil**: The type of soil is determinant when identifying a waste treatment plant. A clay soil, for example, offers impermeability of water and leachate, and therefore, to the introduction of contaminants into the soil. However, it should be noted that clay soil also tends to crack during dry seasons, thus allowing contaminants to penetrate into the soil. Therefore, although clay soil offers a natural barrier, the level of humidity maintained in the soil is determinant. Further protection such as geomembranes, to eliminate all risks associated with MSW management and disposal is therefore necessary.

    - **Depth range of groundwater tables**: In relation to the type of soil, the depth of groundwater must be determined prior to the nomination of a MSW treatment plant site. Often, the first groundwater table cannot be used because of surface contamination. Nevertheless, MSW treatment systems should not be built above shallow groundwater tables, as to avoid potential contamination.

Frame 3. WASTE PRODUCTION AND CHARACTERIZATION

The quantity and especially the characteristics of the waste produced are necessary to verify the possibility of producing compost or generating electricity from a treatment plant. For example, when quantities of waste are too small, electricity-generating systems are not feasible. Moreover, the calorific value of the waste will be determinant for evaluating the possibility of using a thermal treatment. This calorific value can be determined through laboratory analysis, or estimated through a calculation table, which approximates the calorific value of the waste based on the composition of the MSW.



- **TOTAL QUANTITY OF MSW PER DAY:** The quantity of waste produced has an impact on the selection of the MSW treatment and disposal system. When too small a quantity, the use of certain systems such as waste to energy, is not feasible.

- **% by weight**: The waste characterization is broken down into 13 separate categories.
    - **Leaves and wood** (I.e. cut grass, flowers, leaves, small branches, etc.)
    - **Fruits, vegetables and food** (I.e. table scraps, fresh market waste, food waste, etc.)
    - **Paper and cardboard** (I.e. paper bags, wrapping paper, newspapers, magazines, boxes, corrugated boxes, egg cartons, etc.)
    - **Textiles** (I.e. wrapping fibers for fruits and vegetables, clothing, cloths, material bags, socks and stockings, etc.)
    - **Sanitary textiles** (I.e. disposable diapers, sanitary napkins, cotton swabs, paper tissues, household paper, etc.)
    - **Glass** (I.e. bottles, jars, lamp bulbs, etc.)
    - **Plastics** (I.e. film, plastics, PVC, polystyrene egg trays, milk bottles, plastic pipes, toys, etc.)
    - **Metals** (I.e. cans, aluminum foil, yogurt tops, pots and pans, copper wires, etc.)
    - **Unclassified Flammable** (I.e. wrapping cheese packs, fruit trays, egg boxes, etc)
    - **Unclassified non-flammable** (I.e. rocks, gravel, potteries, shells, etc.)
    - **Composites** (I.e. wrapping made of paper, plastic, aluminum, tetra packing, coffee bags, etc)
    - **Special waste** (I.e. batteries, aerosols, syringes, wrapping or materials containing paint, varnish or solvents, etc.)
    - **Undetermined (fines)**

- **Calorific value of waste MJ/kg:** The characterization of the waste is necessary to verify the calorific value of the system. The DMT uses standardized textbook calorific value to estimate the approximate calorific value of the waste to be treated. A value of below 12.5 MJ/kg is considered unacceptable for incineration.

Frame 4. EXISTING FACILITIES REVIEW

The review of existing facilities is important to understand the dynamic of the municipality. Maybe the municipality merely has a wild landfill and therefore, community members have no or few pre-conceived ideas. If an existing system is having serious problems within the municipality, the people including the decision-makers will not be inclined to select the same system.

- **What system does the community currently have?** The verification of existing facilities within a community offers an idea of what the municipality and the community knows, the level of expertise or technicality of the current system, and how the current system is perceived by the municipal administration and community.

- **How does the municipality rate the current waste treatment facility?** A rating of the municipal administration can be determinant in the selection of a treatment system. If viewed in a negative light, the municipality would not be inclined to use the same system, unless the latter was modified and improved substantially.

- **How do community members view the treatment facility?** The views of the community are determinant, for all democratic countries, where people have a voice. In cases where the community is completely against a certain system, it is very difficult for the municipality to implement such a system and therefore a large sensitization and training programme needs to be implemented in order to change public perception.

- **Did the community ever complain about the treatment facility?** When communities often complain against a MSW treatment system, this type of system is viewed in a negative manner and therefore is subject to refusal during a public hearing.

- **Does the facility comply with environmental standards?** When a system does not comply with environmental standards, be they local or international, it

confirms the need for a new treatment system, and at the same time, shows the lack of law enforcement of weakness in its implementation, or altogether its non-existence.

- **How many years has the facility been in operation?** When a system has been in operation for several years, there is generally public acceptation of the said system, whether within standards or not.

- **How many years of operating life are left for the facility?** The number of years of life of the said installation confirms the need or no of a new facility. If less than five years of use are left for the existing facility, a new facility, whether same or different, will be required and therefore preparation should start as soon as possible.

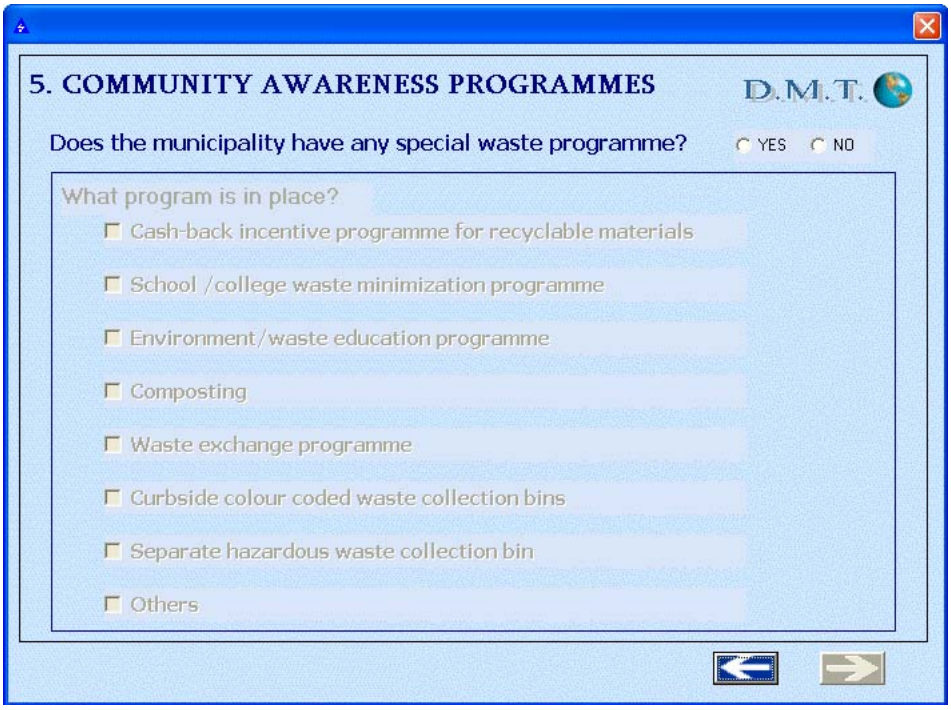
- **Is there a compaction system?** A compaction system reduces the volume of waste and therefore reduces the costs associated to transport and landfill. However, if compaction occurs before waste separation, reuse of waste for recycling and composting becomes very difficult.

- **Is there a bailing system?** A bailing system is basically the wrapping of the compacted waste, offering the same advantages and disadvantages as those of the compaction systems with a supplemental advantage, which is to eliminate the smell and dust associated with waste handling, whether during transport or its treatment.

- **Is there a transfer station?** A transfer station often serves as a waste separation point, which is advantageous for waste recycling and composting techniques.

Frame 5. COMMUNITY AWARENESS PROGRAMMES

If a community has a community awareness programme regarding waste management, there will be serious concerns on the impacts of the system within the community. However, there should also be more collaboration on continuing such programmes. An extension of such a programme certainly would be in line with the community objectives and therefore these programmes must be taken into consideration.

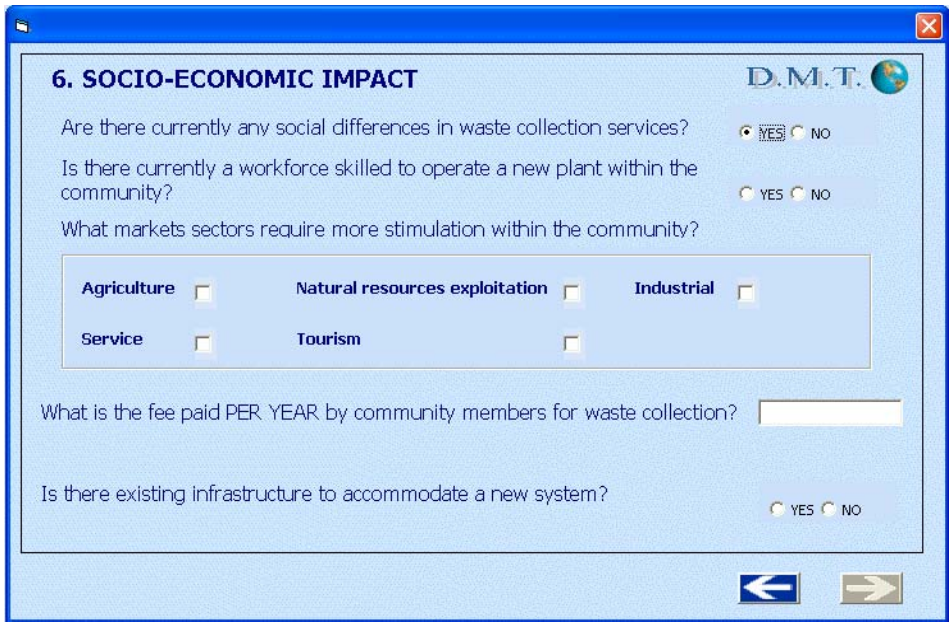


- **Does the municipality have any special waste programme**? A community genuinely concerned about environmental issues will have specific waste programmes within the community. If no programmes have been established, it shows that the community is either not concerned about the environment or that it is at its early stage or it most likely needs support to establish such programmes.

- **If yes, what programme (s) is in place**? Various programmes are in existence and generally help in the management of waste and related treatment techniques such as recycling and composting.
    - **Cash-back incentive programme for recyclable materials** (positive for recycling techniques and for elimination techniques)
    - **School /college waste minimization programme** (positive for recycling techniques and for elimination techniques)
    - **Environment/waste education programme** (positive for recycling techniques and for elimination techniques)
    - **Composting** (positive for recycling techniques, for elimination techniques, and for the promotion of compost utilization)
    - **Waste exchange programme** (positive for recycling techniques and for waste reduction techniques)
    - **Curbside color coded waste collection bins** (positive for recycling techniques, for elimination techniques, and for the promotion of compost utilization)
    - **Separate hazardous waste collection bin** (excellent for waste reuse and composting as to limit the levels of contamination)
    - **Other** (many other programmes may be efficient and in some instances detrimental to certain waste treatment techniques)

Frame 6. SOCIO-ECONOMIC IMPACT

The socio-economic impact of a new MSW treatment plant is crucial in order to justify the costs involved for the new treatment system. Therefore, creation of employment is usually one of the most justifiable explanations. Moreover, it is necessary to ensure that the new system will not have negative effects on the municipality and its community member.



- **Are there currently any social differences in waste collection services?** In many developing countries, there may be a difference in the collection services offered to the wealthier community compared to the poor community. This means that the type of waste collected is not necessarily representative of the whole community, should most or all of the waste be collected. There is also a significant difference between the urban and rural area, in both the type of waste and in the level of efficiency of the waste collected.

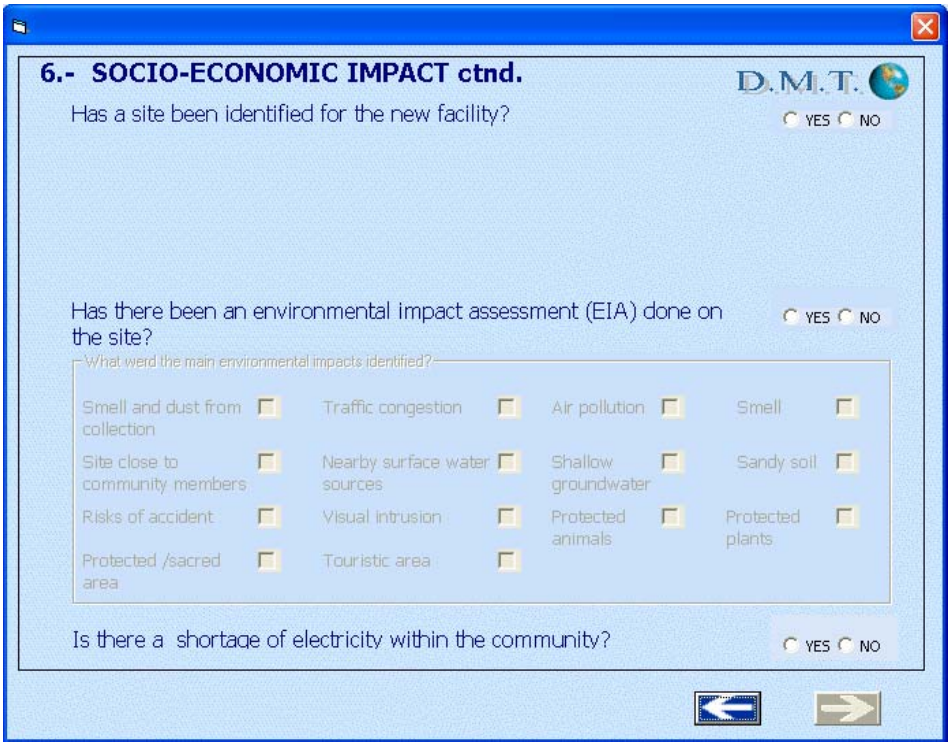
- **Is there currently a workforce skilled to operate a new plant within the community** The level of technical skills available within community members will help determine the technical complexity of the system. This level may be different from what is available at country level.

- **What market sectors require more stimulation within the community?** Each community generally has its local objectives and therefore these must be taken into consideration when selecting a treatment system for the community.

- **What is the fee paid by community members for waste collection?** The fee paid by community members is determinant on the available budget for waste management. Although parallel income from taxes may be in place, if the collection fee is low or non-existent, it will be difficult to ensure the operation and maintenance costs of a high-tech system.

- **Is there existing infrastructure to accommodate a new system?** Infrastructure is necessary to build and operate a treatment plant. If the need for a treatment

plant is in a location where there is little or no infrastructure available, this means that a basic disposal system would be more appropriate. Otherwise, specific and certainly costly infrastructure would be required prior to the installation of the MSW treatment plant.



- **Has a site been identified for the new facility?** When a site has been identified, an EIA should follow as to verify its impact on the environment.

- **Is the selected site one that already has a waste treatment system?** If the site already has a treatment system, the impact of a new system should be lower. Obviously, if the existing site does not comply with environmental standards, this would be verified and notified in the EIA.

- **If yes, what system is present on the site?** The type of system existing on the site also gives an idea on the potential impacts that have been acceptable to the municipality and the community in the past.

- **Has there been an environmental impact assessment (EIA) done on the site?** If no EIA has been made on the site, environmental issues and potential problems could emerge, thus creating problems in the implementation of the new MSW treatment system.

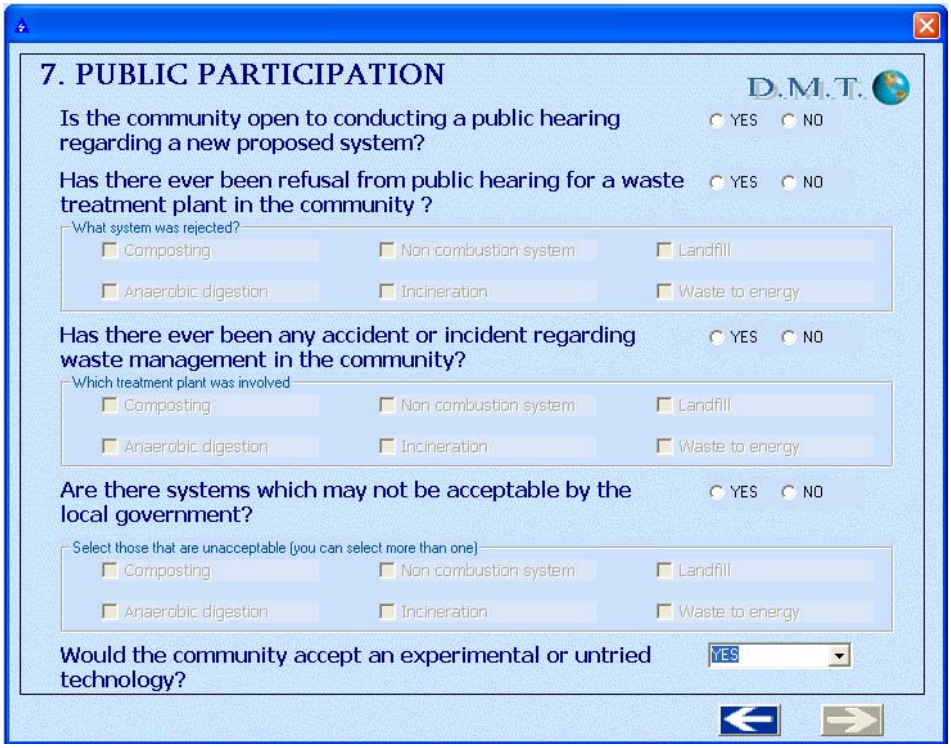
- **If yes, what were the main environmental impacts identified?** If an EIA was done, specific impacts may have been identified, which may lead to problems in the implementation of the MSW treatment system.

- **Is there a shortage of electricity within the community?** The shortage of electricity in developing countries is a frequent situation. Therefore, although

waste to energy systems may be more costly, they may be useful contributors to a community's development by supplying the required energy.

Frame 7. PUBLIC PARTICIPATION

Public participation is the best way to ensure that a new treatment system will be readily accepted by the community. This is usually done by a special committee responsible to follow the various steps in the selection of the new treatment system during the preparation stage, from the inception phase up to the implementation stage. Then, the committee is in a good position to present findings to the community, help justify the preferred selected systems and assure of complete transparency to the community during the public hearing.



- **Is the community open to conducting a public hearing regarding a new proposed system?** Most communities will require a public hearing prior to the acceptation of any MSW treatment systems. Few will not need the public hearing, thus facilitating the selection and implementation of a new treatment system.

- **Has there ever been refusal from public hearing for a waste treatment system in the community?** In some cases, certain systems have been rejected from a public hearing, making this particular system difficult if not impossible to implement in the community.

- **If yes, what system was rejected?** The rejected system is almost certain to be refused in future public hearings, unless specific arguments and justification can be used to convince the community.

- **Have there ever been any problems or incidents regarding waste management in the community?** When problems or incidents occur during the use of a specific treatment system, the population tends to resent this specific treatment system.

- **If yes, which treatment system was involved.** The treatment system involved in the problem is considered as inappropriate to community members and to the local administration.

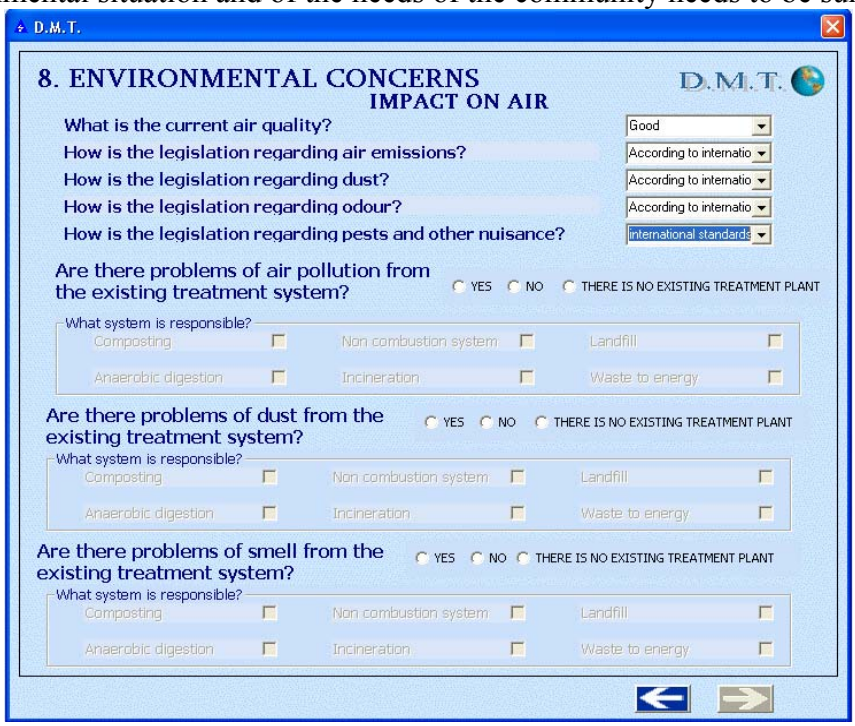
- **Are there systems that may not be acceptable by the local government?** Depending on local policy, certain treatment systems may be considered as unacceptable to local administrations.

- **If yes, select those that are unacceptable (you can select more than one):** Those systems that are considered unacceptable will not be favored by a community, whether this unacceptability is justified or not.

- **Would the community accept an experimental or untried technology?** In most communities, an experimental or untried technology would not be acceptable because of the lack of technical expertise to assess the technology and therefore the fear of the unknown. In some cases, certain agreements may be made when sufficient justification of the safety and advantages of the technology can be proven. In other cases, unfortunately, financial compensation is offered and accepted by the local community, regardless of the safety and environmental issues, which is certainly detrimental to the community.

Frame 8. ENVIRONMENTAL CONCERNS

Environmental protection is an obvious concern when establishing a new MSW treatment system. Therefore, a review of laws, of regulations, of the current environmental situation and of the needs of the community needs to be summarized.



- IMPACT ON AIR The impact of a MSW treatment system on the environment is one of the considerations for administrative and community approval.
    - **What is the current air quality?** In cases where air quality is very good, the concept of air contamination jeopardizes the implementation of a treatment system. In the same manner, if air quality if low, the treatment plant should help improve or at least not worsen the situation.

    - **How is the legislation regarding air emissions?** Existing national and local legislation along with their enforcement will determine the type and level of efficiency of air pollution mitigation required on the MSW treatment system.

    - **How is the legislation regarding dust?** Existing national and local legislation along with their enforcement will determine the type and level of efficiency of dust minimization equipment required on the MSW treatment system.

    - **How is the legislation regarding odor?** Existing national and local legislation along with their enforcement will determine the type and level of efficiency of odor control required on the MSW treatment system.

    - **How is the legislation regarding pests and other nuisance?** Existing national and local legislation along with their enforcement will determine the type and level of efficiency of pest and nuisance control required on the MSW treatment system.

    - **Are there problems of air pollution from the existing treatment system?** If the existing treatment system is responsible for air pollution problems, this type of system will be perceived negatively.

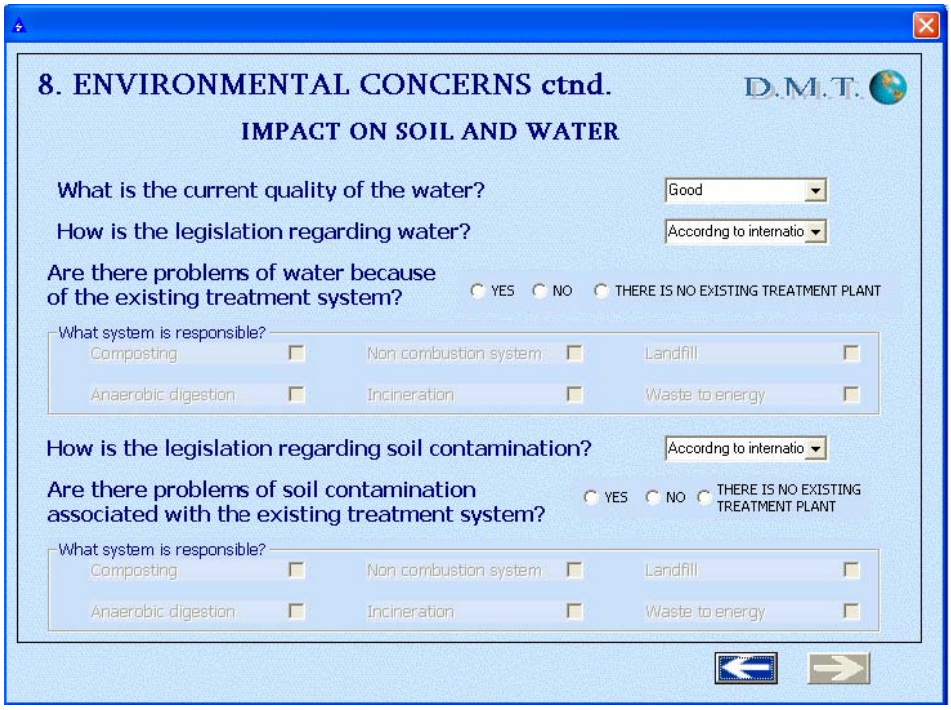
    - **If yes, what system is responsible?** The system creating the problem will be perceived as a problem system and therefore negatively.

    - **Are there problems of dust from the existing treatment system?** If the existing treatment system is responsible for dust problems, this system will be perceived negatively.

    - **If yes, what system is responsible?** The system creating the problem will be perceived as a problem system and therefore negatively.

    - **Are there problems of smell from the existing treatment system?** If the existing treatment system is responsible for smell problems, this system will be perceived negatively.

    - **If yes, what system is responsible?** The system creating the problem will be perceived as a problem system and therefore negatively.



- IMPACT ON SOIL AND WATER The impact of a MSW treatment system on the environment is one of the considerations for administrative and community approval. Protection of surface water spreads and groundwater is crucial to ensure the community's safety and health.

    - **What is the current quality of the water?** In cases where water quality is very good, there is often higher concern regarding water contamination. If water is already contaminated, further contamination could be extremely dangerous to the local community and its environment.

    - **How is the legislation regarding water?** Existing national and local legislation along with their enforcement will determine the type and level of efficiency of pollution mitigation equipment required on the MSW treatment system.

    - **Are there problems of water because of the existing treatment system?** If the existing treatment system is responsible for water pollution problems, this system will be perceived negatively.

    - **If yes, what system is responsible?** The system creating the problem will be perceived as a problem system and therefore negatively.

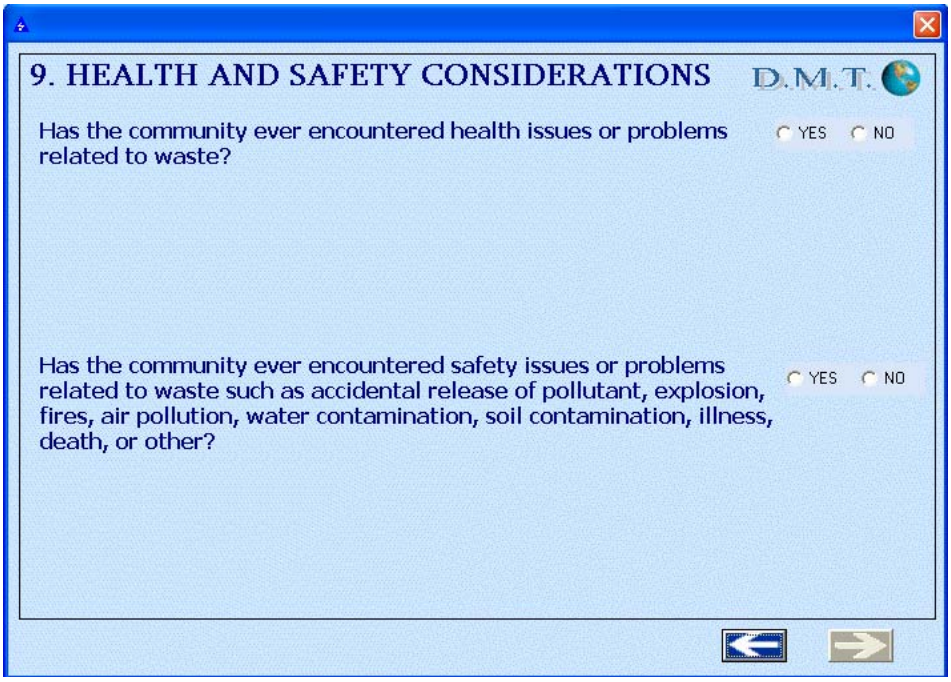
    - **How is the legislation regarding soil contamination?** Existing national and local legislation along with their enforcement will determine the type and level of efficiency of soil contamination mitigation required on the MSW treatment system.

    - **Are there problems of soil contamination associated with the existing treatment system?** If the existing treatment system is responsible for soil contamination problems, this system will be perceived negatively.

- **If yes, what system is responsible?** The system creating the problem will be perceived as a problem system and therefore negatively.

Frame 9. HEALTH AND SAFETY CONSIDERATIONS

Health and safety concerns, although low on many government agendas, especially for small and poor communities, need to be addressed specifically as to improve the quality of life of the people. Therefore, a review of the past and existing health and safety problems related to waste and waste treatment plants offers a fast and direct way to understand the concerns and to avoid similar problems in the future.



- **Has the community ever encountered health issues or problems related to waste?** This question is to create more awareness on the importance of health issues related to MSW and its treatment.

- **If yes, were the issues related to the waste treatment plant?** It could be that the MSW was responsible for health problems until a treatment plant was installed, which then resolved the problem.

- **If so, which system had the problem?** It could also be that the inefficiency of a treatment plant allowed contaminants to enter the community and create health problems.

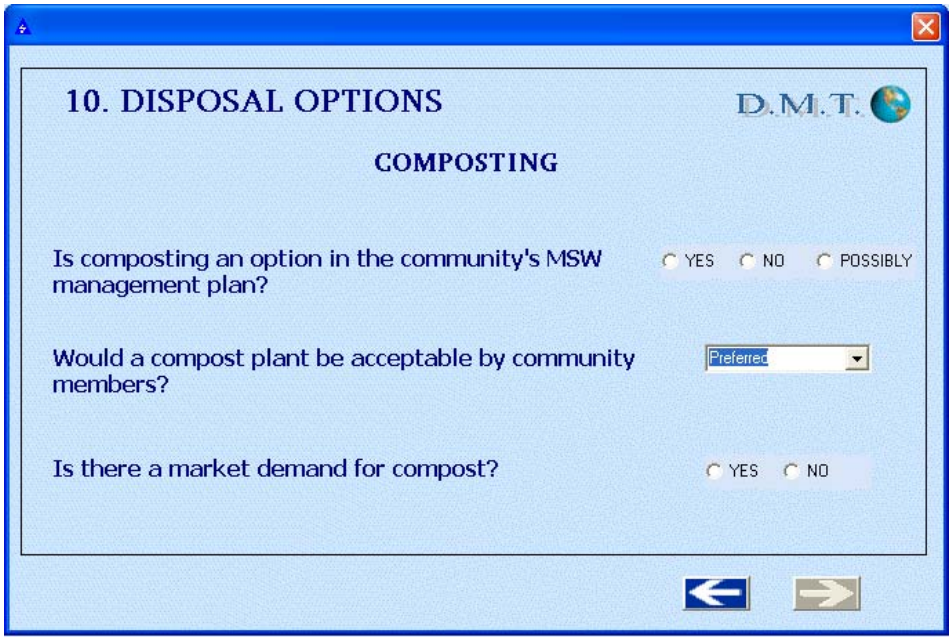
- **Has the community ever encountered safety issues or problems related to waste such as accidental release of pollutant, explosion, fires, air pollution, water contamination, soil contamination, illness, death, or other?** The same applies to safety issues. This question is also to create more awareness on the importance of health issues related to MSW and its treatment.

- **If so, was the treatment plant responsible for the safety issue?** Again, it could be that the MSW was responsible for safety problems until a treatment plant was installed, which then resolved the problem.

- **If yes, which system was involved?** It could also be that that a faulty operation of the treatment plant allowed some kind of accident. It could be due to mismanagement, or from poor control over the treatment plant site.

Frame 10. DISPOSAL OPTIONS

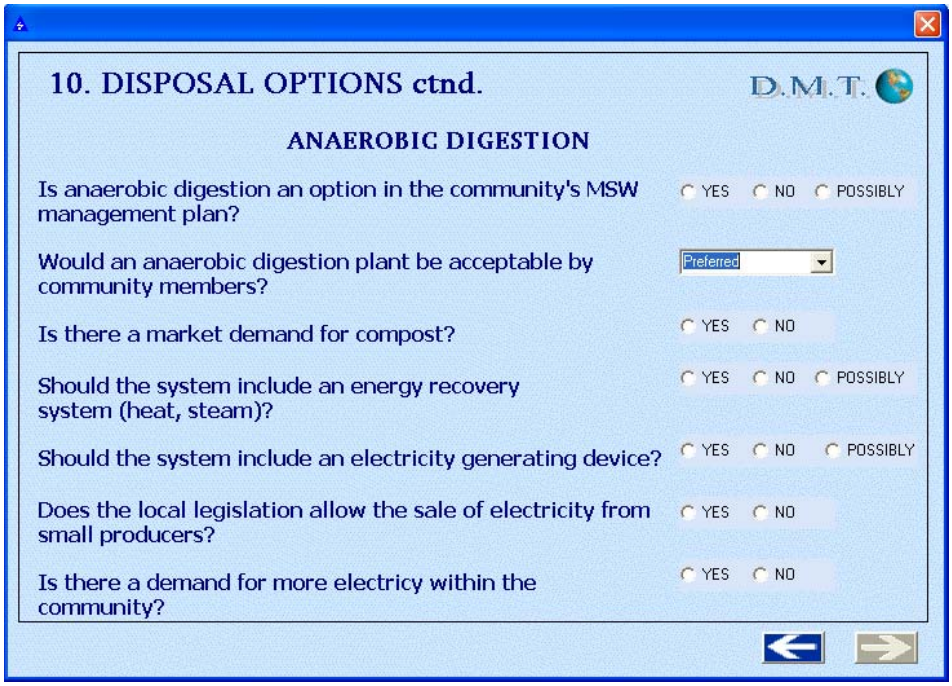
Disposal options have been limited to six. These six options already cover a wide range of sub-options and especially, various techniques that can be used for each of the MSW treatment system. These options offer the decision-maker an opportunity to give his or her preferences and those of the community members. Although this part certainly gives way to subjectivity on the part of the decision-maker, it also offers a voice to community members as to what would be acceptable and unacceptable, in their opinion.



- COMPOSTING
  - **Is composting an option in the community's MSW management plan?** It is determinant to know whether composting is an option for the municipal administration. If it is not, it will be much more difficult to implement.

  - **Would a compost plant be acceptable by community members?** Community members have their say in the selection of a treatment system since without their approval, implementation will be virtually impossible.

  - **Is there a market demand for compost?** A compost plant should be market driven. If there is no market where to sell the compost, or if the market is already saturated with compost, the investment cost for the compost plant will not be justifiable and certainly not feasible.



- ANAEROBIC DIGESTION
  - **Is anaerobic digestion an option in the community's MSW management plan?** It is determinant to know whether anaerobic digestion was considered as an option by the municipal administration. If it is not, it will be much more difficult to implement.

  - **Would an anaerobic digestion plant be acceptable by community members?** Community members have their say in the selection of a treatment system since without their approval, implementation will be virtually impossible.

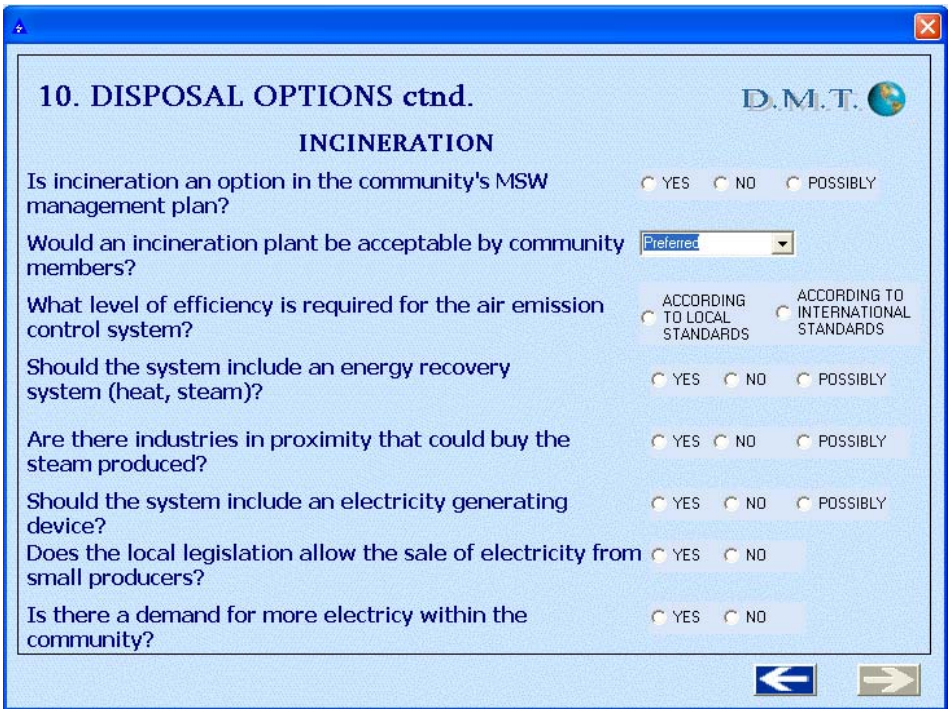
  - **Is there a market demand for compost?** An anaerobic digestion plant should be market driven. If there is no market for compost, then the value of energy production will be the only way of justifying the plant's feasibility and viability.

  - **Should the system include an energy recovery system (heat, steam)?** The main purpose of an anaerobic digester is the production of energy in the form of heat and steam, and compost. Therefore, the energy recovery system in an anaerobic digester plant is crucial.

  - **Should the system include an electricity-generating device?** The cost of an electricity-generating device is significant. However, without this device, the plant may not be feasible.

  - **Does the local legislation allow the sale of electricity from small producers?** In cases where the local legislation does not allow the sale of electricity by small producers, this system may not feasible, unless the electricity can be utilized locally.

- **Is there a demand for more electricity within the community?** If the community is in need of electricity, the additional costs associated with the system and that of an electricity-generating device may offer the community the electricity or part of the electricity needed to further its development, thus justifying the additional investment costs.



- INCINERATION
  - **Is incineration an option in the community's MSW management plan?** It is determinant to know whether incineration was considered as an option by the municipal administration. If it is not, it will be much more difficult to implement.

  - **Would an incineration plant be acceptable by community members?** Community members have their say in the selection of a treatment system since without their approval, implementation will be virtually impossible.

  - **What level of efficiency is required for the air emission control system?** An APC (Air pollution control) system is necessary on all incineration plants. However, these systems have various levels of efficiency ranging from very low to 99.99%. With high efficiency come high costs and therefore, the norms to be followed will determine the level of efficiency thus the price of the system.

  - **Should the system include an energy recovery system (heat, steam)?** One of the options for an incinerator is the recovery of produced energy in the form of heat and steam.

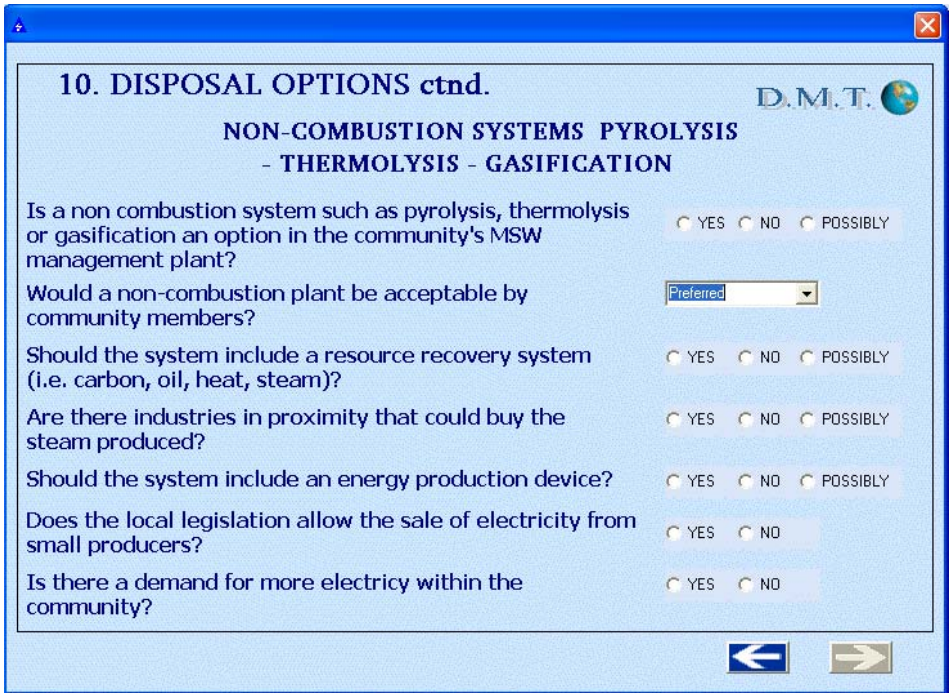
  - **Are there industries in proximity that could buy the steam produced?** The recovery of energy will be justified by the possibility of selling the

by-products to nearby industries. If no buyers are available, this recovery may not be feasible.

- **Should the system include an electricity-generating device?** The cost of an electricity-generating device is significant. The local need for supplemental electricity or the possibility to sell electricity may justify the additional investment cost.

- **Does the local legislation allow the sale of electricity from small producers?** In cases where the local legislation does not allow the sale of electricity by small producers, the electricity-generating device may not be feasible, unless electricity can be utilized locally.

- **Is there a demand for more electricity within the community?** If the community is in need of electricity, the additional costs associated with the system and that of an electricity-generating device may offer the community the electricity or part of the electricity needed to further its development, thus justifying the additional investment costs.



- NON-COMBUSTION SYSTEMS PYROLYSIS - THERMOLYSIS - GASIFICATION
  - **Is a non-combustion system such as pyrolysis, thermolysis or gasification an option in the community's MSW management plant?** It is determinant to know whether non-combustion was considered as an option by the municipal administration. If it is not, it will be much more difficult to implement.

  - **Would a non-combustion plant be acceptable by community members?** Community members have their say in the selection of a

treatment system since without their approval, implementation will be virtually impossible.

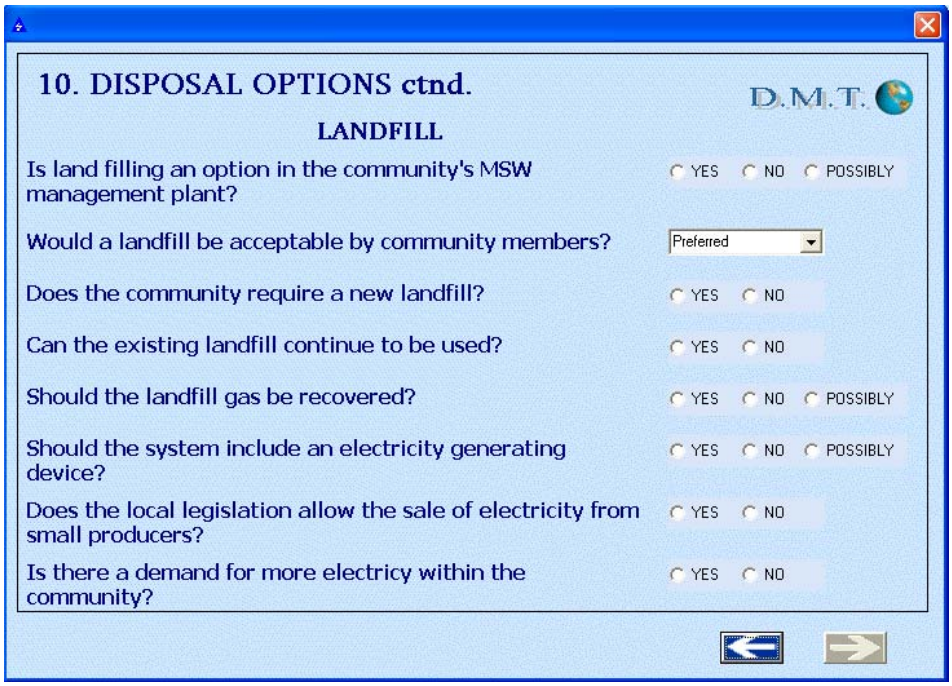
- **Should the system include a resource recovery system (i.e. carbon, oil, heat, steam)?** The main purpose of a non-combustion system is the production of by-products that can be sold. Should there be no interest in resource recovery or no market for the by-products, this system would not be appropriate.

- **Are there industries in proximity that could buy the steam produced?** The proximity of buyers of steam is necessary if steam is to be sold. Otherwise, this steam could be used locally to generate electricity.

- **Should the system include an energy production device?** Energy can be produced from various by-products of the non-combustion system (from the carbon, from the oil, from the heat, from the steam). Obviously, different devices need to be used for these different fuel types. This will need to be evaluated in details if this option is selected.

- **Does the local legislation allow the sale of electricity from small producers?** In cases where the local legislation does not allow the sale of electricity by small producers, the electricity-generating device may not be feasible, unless electricity can be utilized locally.

- **Is there a demand for more electricity within the community?** If the community is in need of electricity, the additional costs associated with the system and that of an electricity-generating device may offer the community the electricity or part of the electricity needed to further its development, thus justifying the additional investment costs.



- LANDFILL
    - **Is land filling an option in the community's MSW management plant?** It is determinant to know whether a landfill was considered as an option by the municipal administration. If it is not, it will be much more difficult to implement.

    - **Would a landfill be acceptable by community members?** Community members have their say in the selection of a treatment system since without their approval, implementation will be virtually impossible.

    - **Does the community require a new landfill?** If there is no need for a new landfill, this option may not be acceptable.

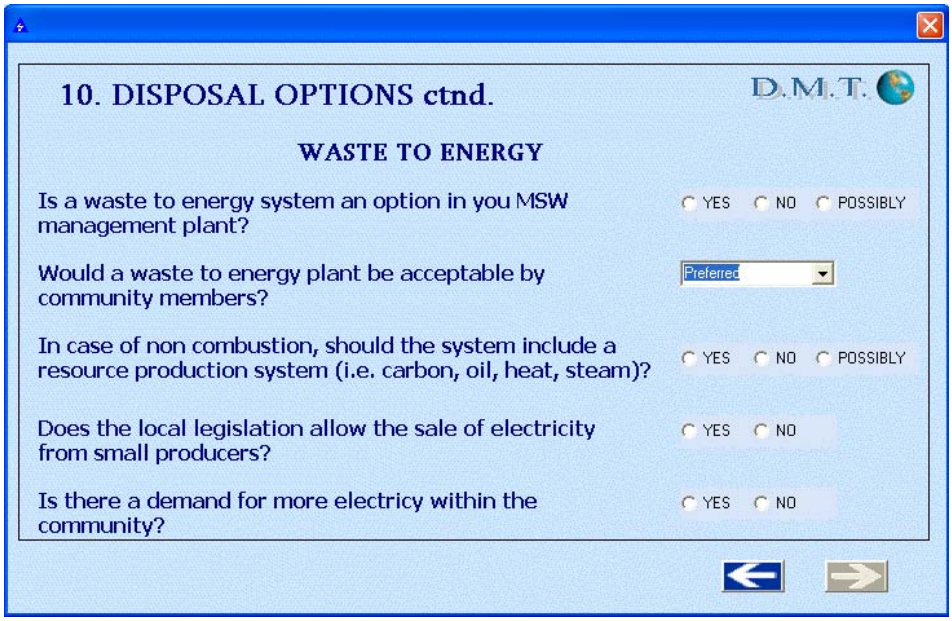
    - **Can the existing landfill continue to be used?** If the existing landfill can continue to be used, then there is no need for a new landfill. If not, then a landfill is necessary, whether as a primary MSW disposal site, or for ultimate waste, residuals from MSW treatment systems.

    - **Should the landfill gas be recovered?** Recovery of landfill gas will contribute to the reduction of greenhouse gases associated with the production of landfill gas. Special credits can be awarded to a landfill site that recovers the gas, either to flare or to use in the production of electricity.

    - **Should the system include an electricity-generating device?** The feasibility of electricity generation from landfill gas will be determined by the quantity of gas recovered from the landfill.

    - **Does the local legislation allow the sale of electricity from small producers?** In cases where the local legislation does not allow the sale of electricity by small producers, the electricity-generating device may not be feasible, unless electricity can be utilized locally.

    - **Is there a demand for more electricity within the community?** If the community is in need of electricity, the additional costs associated with the system and that of an electricity-generating device may offer the community the electricity or part of the electricity needed to further its development, thus justifying the additional investment costs.



- WASTE TO ENERGY
  - **Is a waste to energy system an option in you MSW management plant?** It is determinant to know whether waste to energy was considered as an option by the municipal administration. If it is not, it will be much more difficult to implement.

  - **Would a waste to energy plant be acceptable by community members?** Community members have their say in the selection of a treatment system since without their approval, implementation will be virtually impossible.

  - **In case of non-combustion, should the system include a resource production system (i.e. carbon, oil, heat, steam)?** The main purpose of a non-combustion system is the production of by-products that can be sold. Should there be no interest in resource recovery, this system would not be appropriate.

  - **Does the local legislation allow the sale of electricity from small producers?** In cases where the local legislation does not allow the sale of electricity by small producers, the electricity-generating device may not be feasible, unless electricity can be utilized locally.

  - **Is there a demand for more electricity within the community?** If the community is in need of electricity, the additional costs associated with the system and that of an electricity-generating device may offer the community the electricity or part of the electricity needed to further its development, thus justifying the additional investment costs.

Issue 11. SYSTEM COSTING (no frame)

System costing is a major issue when choosing a waste treatment system. However, this decision-making framework is not a cost analysis framework. Therefore, costing was ranked and not based on specific and predetermined costs. This decision-making tool ranks systems according to their investment and to the operation and maintenance costs in a comparative manner, without basing the decision on a specific price associated to a specific system. Once a system or integrated system has been identified, a feasibility study will be required to verify the viability of the system, taking into consideration investment costs, operating and maintenance costs, and income from by products, which may include the sale of recyclable materials, compost, steam, heat, electricity, charcoal, oil…

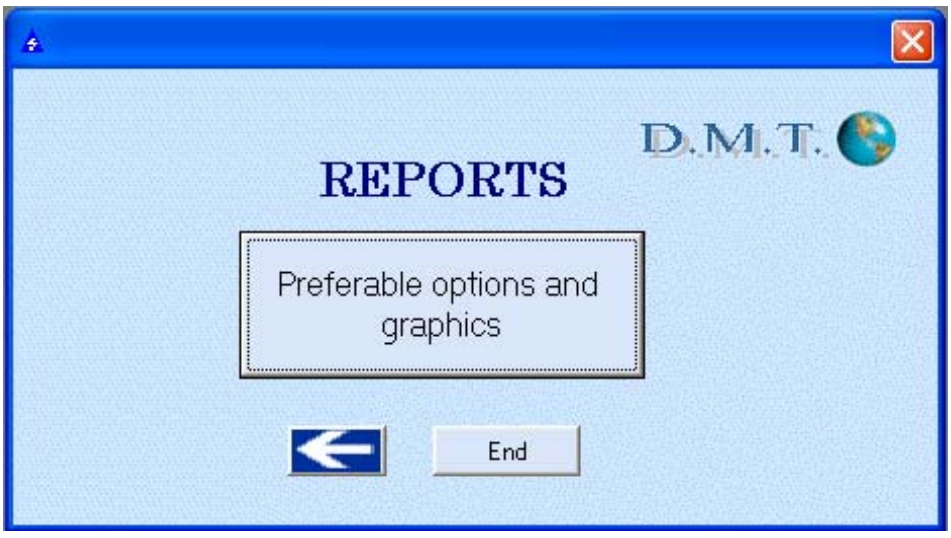
No questions were submitted to this section. Values were inserted as follows:

- **Investment cost:** Investment costs were graded in order of costs (from most expensive to least expensive) and not based on specific costs.

- **Operation and maintenance costs:** Operation and maintenance costs were graded in order of operational and maintenance costs (from most expensive to least expensive) and not based on specific costs.

Frame REPORTS

Preferable options and graphics



This section presents the computerized results of the data analysis, evaluating each treatment system in a scoring manner. The higher the result, the most appropriate the solution for the municipality.

Frame 11 WASTE DISPOSAL SCENARIO ANALYSIS

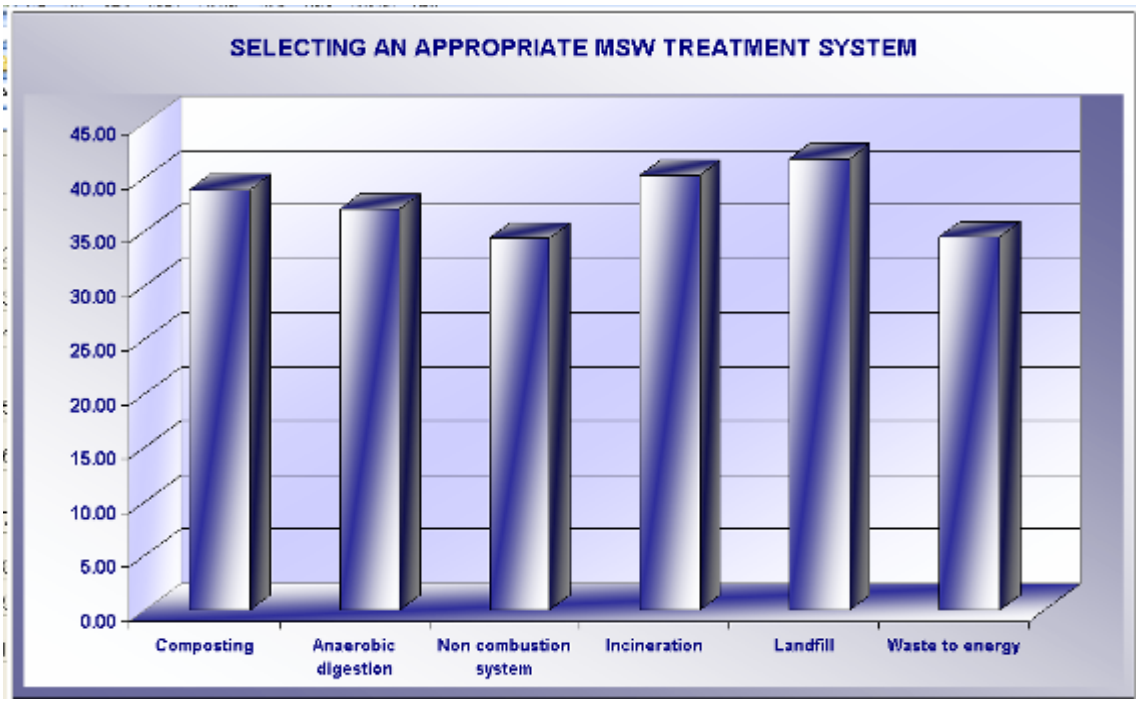
11. WASTE DISPOSAL SCENARIO ANALYSIS						
ANALYSIS	Composting	Anaerobic digestion	Non combustion system	Incineration	Landfill	Waste to energy
1. GENERAL DESCRIPTION	4.00	3.00	3.00	3.00	3.50	3.00
2. CLIMATIC CONDITIONS	4.50	4.50	3.50	3.50	1.50	3.50
3. WASTE PRODUCTION AND CHARACTERIZATION	1.50	1.00	1.00	1.00	1.50	1.00
4. EXISTING FACILITIES REVIEW	0.00	0.00	0.00	4.50	5.50	0.00
5. COMMUNITY PROGRAMMES	3.00	3.00	3.00	2.00	3.00	2.00
6. SOCIO-ECONOMIC IMPACT	6.00	5.00	5.00	4.00	6.00	5.00
7. PUBLIC PARTICIPATION	4.50	4.50	3.50	4.50	4.50	4.50
8. ENVIRONMENTAL CONCERNS	8.00	8.00	8.00	8.00	8.00	8.00
9. HEALTH AND SAFETY CONSIDERATIONS	3.00	3.00	3.00	3.00	3.00	3.00
10. DISPOSAL OPTIONS	2.75	4.50	3.75	5.50	3.25	4.50
DISPOSAL ANALYSIS	38.85	37.10	34.35	40.20	41.75	34.50

THE HIGHER THE NUMBER THE MOST APPROPRIATE THE SYSTEM

Frame 11. WASTE DISPOSAL SCENARIO ANALYSIS summarizes the accumulative values for each of the questionnaire frames. Each of the ten frames adds the values accumulated, according to the answers provided. These values range between "0" and "1", one being the highest and better score, zero being the worst case. Zero is also used when there is inexistence of a system or situation, and therefore no comparative value. Scoring is made on a comparative basis rather than on a direct allocated value. Each of the six treatment systems show a value based on the answers provided throughout the questionnaire for each of the 10 questionnaire frames plus the investment, operation and maintenance values. The accumulated value for each of the frames is reflected in Frame 11 for each questionnaire frame (y-axis) and for each of the compared waste treatment system (x-axis).

The total accumulated points are then given in the last line DISPOSAL ANALYSIS" giving a total value for each of the six potential waste treatment systems. The higher value, which means the higher score, indicates what would be the most acceptable system for the community based on the answers provided in the questionnaire. These values are to be used in the design of the integrated MSWM system elaborated in Frame 12 and Frame 13.

The next frame SELECTING AN APPROPRIATE MSW TREATMENT SYSTEM summarizes the data from Frame 11 WASTE DISPOSAL SCENARIO ANALYSIS and presents the data from the DISPOSAL ANALYSIS line into a graphic representation. This allows the decision maker to visually see what would be the most acceptable treatment system, in a comparative manner.



In the example provided, one can clearly see the results demonstrated through the various columns. In the above, landfill is preferred along with incineration. The third and most likely complementary system would be a composting system. An anaerobic digestion could combine the need for compost and the production of energy.

Frame 12 COMPARATIVE ANALYSIS FOR FOUR INTEGRATED WASTE TREATMENT SCENARIOS

12. COMPARATIVE ANALYSIS FOR FOUR INTEGRATED WASTE TREATMENT SCENARIOS

	Community objective	Alternative scenario 1	Alternative scenario 2	Alternative scenario 3
Recycling	20%	20%	15%	20%
Composting	20%	20%	0%	0%
Anaerobic digestion	0%	0%	40%	0%
Non combustion	0%	0%	0%	30%
Incineration	0%	0%	0%	0%
Landfill	20%	60%	45%	50%
Waste to energy	40%	0%	0%	0%
TOTAL	100%	100%	100%	100%
Analysis SCORE	39.92	42.82	41.13	41.18

Enter values in yellow to verify various alternative scenarios

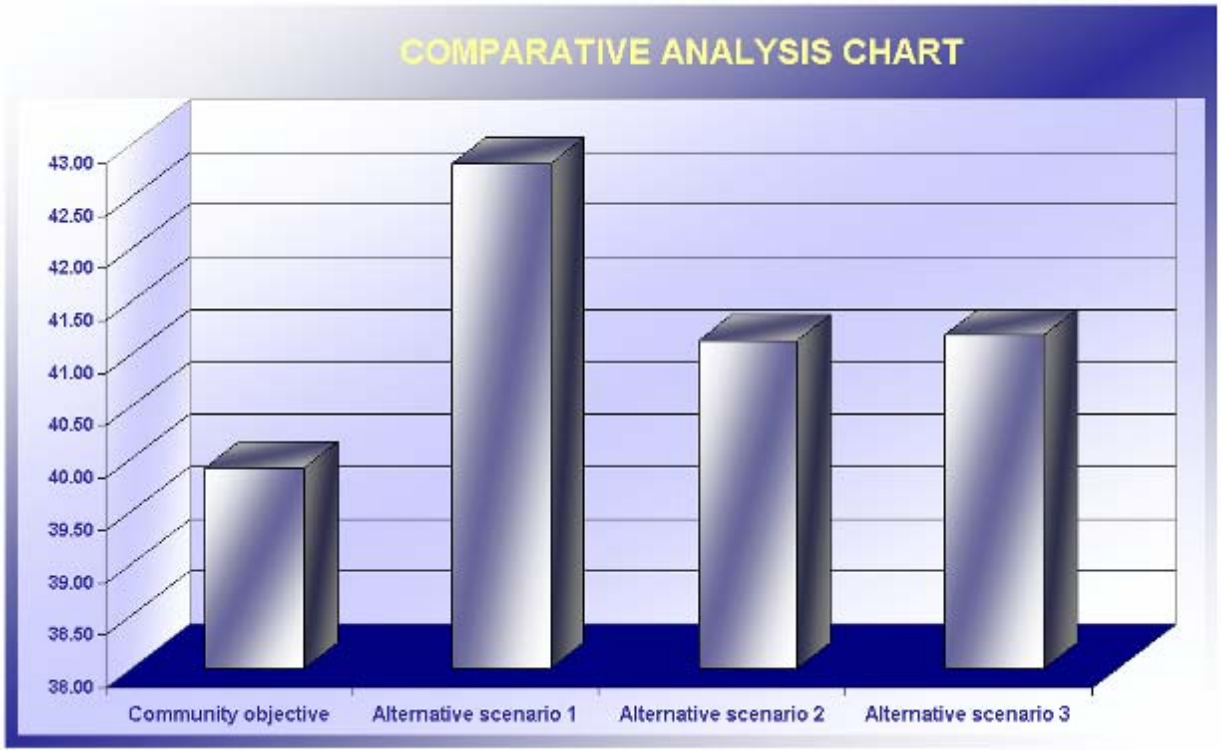
Analysis result: The higher the score, the better the option.

The objective of Frame 12 COMPARATIVE ANALYSIS FOR FOUR INTEGRATED WASTE TREATMENT SCENARIOS is to allow the decision maker to evaluate various case scenarios in the selection of the most appropriate integrated MSWM system. The decision maker is required to enter percentage values of what he or she thinks are the most feasible techniques to be used in its MSWM plan. Recycling has been added as one of the integrated management option. Although it is part of a MSWM plan, it is not a treatment and therefore was not part of the MSW treatment system comparative charts. It was, however, considered in the questionnaire.

The first column is for the decision maker to enter the values deemed appropriate for the community, namely, for the community objective. Then, three alternative scenarios are to be entered as to compare the suitability of the community's objective. Values are calculated based on the values collected in Frame 11. The result may prove that the community objective is the most appropriate, or that one of the alternatives would be more appropriate for the community. In the above example, alternative scenario 1 appears to be more appropriate and feasible to the community based on the data analysis values from frame 11.

The conclusion of this analysis is an integrated approach, which allows the recycling of materials while combining a number of other disposal techniques in the elimination of MSW.

The next frame COMPARATIVE ANALYSIS SCORE is the graphic representing the findings from the COMPARATIVE ANALYSIS FOR FOUR INTEGRATED WASTE TREATMENT SCENARIOS.



One can graphically see the community objective compared to other three case scenarios for an integrated MSW management system. In the above example, alternative scenario 1 offers a clear advantage over that of the community objective.

Frame 13 FIFTEEN YEARS WASTE MANAGEMENT PLANNING; COMPARING FOUR CASE SCENARIOS

13. FIFTEEN YEARS WASTE MANAGEMENT PLANNING; COMPARING FOUR CASE SCENARIOS

Enter values in yellow section to compare four case scenarios over the next 15 years

Community objectives

Total waste to be treated Year 1 : **34.00**

SCORES

The higher the score, the better the option

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	20%	6.80	30%	11.15	30%	12.19	30%	13.33
Composting	20%	6.80	20%	7.43	20%	8.13	20%	8.89
Anaerobic digestion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Non combustion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Incineration	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Landfill	20%	6.80	10%	3.72	10%	4.06	10%	4.44
Waste to energy	40%	13.60	40%	14.87	40%	16.26	40%	17.77
TOTAL (total must be 100%)	100%	34.00	100%	37.17	100%	40.64	100%	44.43

Community objectives analysis result **147.63**

Alternative scenario 1

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	20%	6.80	20%	7.43	25%	10.16	25%	11.11
Composting	20%	6.80	20%	7.43	20%	8.13	20%	8.89
Anaerobic digestion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Non combustion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Incineration	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Landfill	60%	20.40	10%	3.72	5%	2.03	5%	2.22
Waste to energy	0%	0.00	50%	18.59	50%	20.32	50%	22.22
TOTAL (total must be 100%)	100%	34.00	100%	37.17	100%	40.64	100%	44.43

Alternative scenario 1 analysis result **161.23**

Alternative scenario 2

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	15%	5.10	15%	5.58	30%	12.19	30%	13.33
Composting	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Anaerobic digestion	40%	13.60	40%	14.87	40%	16.26	40%	17.77
Non combustion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Incineration	0%	0.00	30%	11.15	0%	0.00	0%	0.00
Landfill	45%	15.30	15%	5.58	30%	12.19	30%	13.33
Waste to energy	0%	0.00	0%	0.00	0%	0.00	0%	0.00
TOTAL (total must be 100%)	100%	34.00	100%	37.17	100%	40.64	100%	44.43

Alternative scenario 2 analysis result **135.21**

Alternative scenario 3

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	20%	6.80	25%	9.29	30%	12.19	35%	15.55
Composting	0%	0.00	10%	3.72	10%	4.06	20%	8.89
Anaerobic digestion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Non combustion	30%	10.20	30%	11.15	30%	12.19	30%	13.33
Incineration	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Landfill	50%	17.00	35%	13.01	30%	12.19	15%	6.66
Waste to energy	0%	0.00	0%	0.00	0%	0.00	0%	0.00
TOTAL (total must be 100%)	100%	34.00	100%	37.17	100%	40.64	100%	44.43

Alternative scenario 3 analysis result **159.77**

The FIFTEEN YEARS WASTE MANAGEMENT PLANNING; COMPARING FOUR CASE SCENARIOS frame utilizes the data of frame 12 as its initial starting point (in blue column) for calculating the percentages for the integrated MSWM system, and allows the user to introduce what is expected to be the development of the MSWM plan over the next 15 years implementation, on a 5 years increment scheme. The results are then added based on the values calculated in Frame 11 and on the percentage for each category, added to give a total score, which is presented on the bottom right of each scenario. The higher the score, the more appropriate the plan. The DMT takes into consideration the increase in population and therefore in the quantity of waste generated, according to the population growth indicated in Frame 1.

These results are then compared in the next graphic frame showing the most appropriate integrated MSW management plan for each option over the 15 years.

One can see in the graphic of this example that the alternative scenario 1 is more appropriate for the community than what had been expected using the community objectives.

5.5.2 UTILIZATION OF ANALYSIS DATA AND PLANNING

Values for the integrated MSWM treatment system can be altered and modified at will by the user. This allows the verification of various case scenarios and the selection of the most appropriate waste treatment system. The system can be as simple as a few treatment systems, and as complex as the selection of multiple systems. In some countries, more than one treatment system is compulsory in its MSWM system. However, the integrated MSWM system can include recycling and landfill, which would already account for two waste treatment systems. Others will depend on local constraints and available budget.

The results offer a fair evaluation of an appropriate integrated MSW treatment system. The limitations of the study are mainly on the exactness and honesty of the response to the questions. The purpose of the DMT is not to review the feasibility of a project but rather its appropriateness for a given community based on social, political, environmental and technical information. Once an appropriate integrated MSWM system has been identified, a detailed feasibility will be required. However, the costs associated with the feasibility study will be reduced since its scope will be limited to few options rather than a full range of options. Moreover, public participation will be facilitated since the role of the community will have been respected.

5.6 DETERMINATION OF OBJECTIVE EVALUATION CRITERIA

Community objectives and participation remain the most crucial part of the decision-making framework. Because these objectives need to be implemented, the municipality is responsible for identifying those objectives, which are most suitable for the social and economic welfare of community members.

Obviously, the strategic management and disposal of MSW are closely linked to the quantity of waste produced within the municipality. For example, the conversion of organic waste into compost is contingent to the market demand for such a product, be it local, to be used in municipal parks and private gardening activities, or external, for sale in other towns, provinces or countries.

The residents of the municipality should be encouraged to separate recyclable materials such as plastic, paper and glass, as to minimize the quantity of waste to be disposed. This activity can also generate employment to certain community members. Municipal administrators must also take into consideration the option for production of electricity, according to local needs and demand. Although the conversion of waste into energy through anaerobic digestion or combustion and non-combustion systems may offer a solution to local electricity shortage, its associated costs must be carefully analyzed. Landfill gas recovery can also be an option, if the quantity of waste, its quality and the age of the landfill allow it.

In view of the above, one can assume that all levels of decision are equally important. The ideas and will of the municipal administrator are highly important. However, in most countries, the community members will have the last say in the decision-making through public hearings and community participation.

5.7 VERIFICATION OF INFORMATION AND CONFIRMATION OF RELIABILITY

The decision-framework was prepared following literature reviews and personal experience in MSW management. It was further verified through interviews and data collection of the city of Bangkok as to ascertain that all key aspects had been properly addressed, and given sufficient importance.

The exactitude, extent and details of information are elements that needed to be determined in their applicability, and necessity to make a well-informed decision on the selection of the appropriate MSW treatment system that should be used for the municipality. The decision-making framework is not focusing on cost-accountability but rather on the social, political and environmental issues involved in the selection of an appropriate MSW treatment system. It further took into consideration the integration of various systems as to optimize the outputs and the feasibility of the MSW treatment system.

This framework was then translated into a decision-making tool, using an Excel base programme as to facilitate the gathering of data from decision-makers, for an auto-evaluation of the most appropriate MSW system for the municipality, and the possible integration of various technologies.

5.8 SECTION SUMMARY

Local governments are responsible for managing MSW in an efficient and sustainable manner to protect the health and well-being of their community members. Governments must therefore select an appropriate waste treatment system to be used in their community, in answer to the needs of the community.

A decision-making framework was developed to include the specific objectives of decision-makers. An appropriate and effective system should be installed as to ensure the protection of the local population and their environments, which will in turn, protect the country's natural resources.

Equipment must be prepared to deal with a humid environment, wet waste and high temperatures. It must also take into consideration recycling which will alter the waste composition. Employment generation is also an important aspect as a social support especially to disadvantaged groups.

The procedure used for the development of the decision-making framework looked at identifying the objectives and key aspects influencing MSW management, the elements involved in each of the aspects, the various options in alternative integrated waste management, the values of acceptability, the elimination of unacceptable options, and the sensitivity of the elements. These aspects were used in the preparation of closed-ended questions towards gathering specific data.

The decision-making issues involved in the framework include a general description of the municipality, its climatic and hydrogeological conditions, the quantity and type of waste produced, a review of existing facilities and existing community awareness programmes, the socio-economic impact of a treatment system and the public participation. They further reviewed health and safety considerations in association with waste disposal options and their costs.

Community objectives and participation are crucial in the successful implementation of a treatment plant. Both municipal administrators and community members have equal voice in the successful implementation, operation and maintenance of a treatment plant, and therefore should both be taken into consideration.

The decision-making framework was prepared based on literature review, personal experience, and was verified through the data collected from the Municipality of Bangkok. It focuses on the social, political and environmental issues involved in the selection of an appropriate MSW treatment system. The framework was then translated as a questionnaire with its result analysis and data management in an Excel base decision-making tool programme.

6. Decision-making tool applied to Bangkok

6.1 DEVELOPMENT OF THE DECISION-MAKING TOOL

Based on the decision-making framework, a decision-making tool was developed in Excel. The decision-making tool consists of a series of more than 100 closed-ended questions to which a public administrator is expected to know or find the answers. These questions were developed based on the decision-framework prepared following literature reviews, interviews and data collection of the city of Bangkok as to ascertain that all key aspects were addressed.

Multiple-choice answers further allowed the self-ponderation of the answers. As stated by Hämäläinen (2003), weighting can be done by the calculation of the number of attributes, in this case, the number of questions related to the same topic. Ranking of criteria is extremely difficult, delicate and often biased. Some weighting procedures, such as those of Aravossis et al (1999) use an indirect weight assignment with the objective of minimizing subjectivity by giving more weight to public administrators. However, This is subjective since the reality of life in communities is that if community members refuse a specific treatment system, it cannot and will not be implemented. Therefore, the weight of the voice of the community is just as strong as that of the city administrators. Therefore, ponderation of the answers is extremely delicate. As such, the decision-making tool uses a self-pondering system, which through the number of questions relating to a same topic, cumulates the responses thus pondering the answer.

The decision-making tool looks at six specific treatment systems as potentially appropriate systems for the municipality. The output analysis not only analyses one potential system but also allows the integration of several systems. It offers the flexibility for public administrators and environmental engineers to change the ratio of the community's objectives as to the quantity of waste recycled, the percentage of waste to be composted, and so on.

All answers are given a specific value, depending on the number of possible answers. These values all range between zero and one, zero being the smallest value and one being the highest value awarded to one answer. Middle or intermediate values are also included. Most questions are closed with multiple-choice answers to each question. Therefore, if a question offers three possible answers, values awarded will be 0, 0.5 and 1. Should the question offer six possible answers, then the values awarded would be 0, 0.2, 0.4, 0.6, 0.8 and 1. This allows an objective and unbiased evaluation system.

These values are then cumulated as to offer the administrator a clear idea of the valuated system in a comparative manner. The whole purpose of this is to compare the six identified options, namely composting, anaerobic digestion, non-combustion systems such as pyrolysis, thermolysis and gasification, incineration, landfill and waste to energy. The higher the value, the most appropriate the system for the municipality.

6.2 RELIABILITY VERIFICATION OF THE DECISION-MAKING TOOL

The exactitude of the information is crucial for proper assessment. This is why the user-friendly decision-making tool is useful to assist decision-makers, public administrators and environmental staff in the preliminary assessment of their needs and review of their options.

As to confirm the workability and reliability of the tools, its results were compared to findings following the waste management study for the city of Bangkok, and using traditional analysis. The results from the decision-making tool showed findings similar to those made during the waste management study for the municipality of Bangkok.

Other municipalities can therefore use this tool as a preliminary review of options, their comparative advantages, and appropriateness to their community.

6.3 BANGKOK DATA REVIEW

QUESTION	ANSWER
1. GENERAL DESCRIPTION	
• Current population	9,000,000
• Population growth	0.4%
• Average monthly salary of personnel	170
• What is the level of technical expertise available	Average
• Is there a need for supplemental electricity within the community	No
2. CLIMATIC HYDROGEOLOGICAL CONDITIONS	
• Maximum temperatures (^{o}C)	33.3
• Minimum temperatures (^{o}C)	24.9
• Wind velocity (km/h)	4.68
• Annual rainfall (cm)	176.45
• Relative humidity (%)	85
• Hydrogeological conditions	
o Type of soil	Clay
o Depth range of groundwater tables (cm)	200
3. WASTE PRODUCTION AND CHARACTERIZATION	
TOTAL QUANTITY OF MSW PER DAY	**9,000**
• **Waste type (% by weight)**	
o **Leaves and wood** (I.e. cut grass, flowers, leaves, small branches, etc.)	**10.82 %**
o **Fruits, vegetables and food** (I.e. table scraps, fresh market waste, food waste, etc.)	**24.83 %**
o **Paper and cardboard** (I.e. paper bags, wrapping	**8.24 %**

paper, newspapers, magazines, boxes, corrugated boxes, egg cartons, etc.)	
○ **Textiles** (I.e. wrapping fibers for fruits and vegetables, clothing, cloths, material bags, socks and stockings, etc.)	**4.45 %**
○ **Sanitary textiles** (I.e. disposable diapers, sanitary napkins, cotton swabs, paper tissues, household paper, etc.)	**1.90 %**
○ **Glass** (I.e. bottles, jars, lamp bulbs, etc.)	**3.90 %**
○ **Plastics** (I.e. film, plastics, PVC, polystyrene egg trays, milk bottles, plastic pipes, toys, etc.)	**22.73 %**
○ **Metals** (I.e. cans, aluminum foil, yogurt tops, pots and pans, copper wires, etc.)	**2.30 %**
○ **Unclassified Flammable** (I.e. wrapping cheese packs, fruit trays, egg boxes, etc)	**3.39 %**
○ **Unclassified non-flammable** (I.e. rocks, gravel, potteries, shells, etc.)	**1.70 %**
○ **Composites** (I.e. wrapping made of paper, plastic, aluminum, tetra packing, coffee bags, etc)	**0.48 %**
○ **Special waste** (I.e. batteries, aerosols, syringes, wrapping or materials containing paint, varnish or solvents, etc.)	**0.17 %**
○ **Undetermined (fines)**	**15.09 %**
• **Calorific value of waste MJ/kg**	**13.50**
4. EXISTING FACILITIES REVIEW	
• What system does the community currently have?	Landfill
• How does the municipality rate the current waste treatment facility?	Good
• How do community members view the treatment facility?	Fair
• Did the community ever complain about the treatment facility?	Often
• Does the facility comply to environmental standards?	Yes
• How many years has the facility been in operation?	15
• How many years of operating life are left for the facility?	10
• Is there a compaction system?	No
• Is there a bailing system?	No
• Is there a transfer station?	Yes
5. COMMUNITY AWARENESS PROGRAMMES	
• Does the municipality have any special waste programme?	Yes
• If yes, what programme (s) is in place?	
○ Cash-back incentive programme for recyclable materials	Y

○ School /college waste minimization programme	Y
○ Environment/waste education programme	Y
○ Composting	Y
○ Waste exchange programme	Y
○ Curbside color coded waste collection bins	Y
○ Separate hazardous waste collection bin	Y
○ Other	Y
6. SOCIO-ECONOMIC IMPACT	
• Are there currently any social differences in waste collection services?	Y
• Is there currently a workforce skilled to operate a new plant within the community	Y
• What market sectors require more stimulation within the community?	Service
• What is the fee paid by community members for waste collection?	14.40
• Is there existing infrastructure to accommodate a new system?	Y
• Has a site been identified for the new facility?	Y
• Is the selected site one that already has a waste treatment system?	No
• If yes, what system is present on the site?	-
• Has there been an environmental impact assessment (EIA) done on the site?	No
• If yes, what were the main environmental impacts identified?	
• Is there a shortage of electricity within the community?	No
7. PUBLIC PARTICIPATION	
• Is the community open to conducting a public hearing regarding a new proposed system?	Y
• Has there ever been refusal from public hearing for a waste treatment system in the community?	No
• If yes, what system was rejected?	-
• Have there ever been any problems or incidents regarding waste management in the community?	Y
• If yes, which treatment system was involved	Landfill, composting, incineration
• Are there systems that may not be acceptable by the local government?	No
• If yes, select those that are unacceptable (you can select more than one)	-
• Would the community accept an experimental or untried technology?	Depends on agreement

8. ENVIRONMENTAL CONCERNS	
• IMPACT ON AIR	
○ What is the current air quality?	Bad
○ How is the legislation regarding air emissions?	According to International standards
○ How is the legislation regarding dust?	Strict
○ How is the legislation regarding odor?	Tolerant
○ How is the legislation regarding pests and other nuisance?	Tolerant
○ Are there problems of air pollution from the existing treatment system?	Yes
○ If yes, what system is responsible?	Landfill
○ Are there problems of dust from the existing treatment system?	Yes
○ If yes, what system is responsible?	Landfill
○ Are there problems of smell from the existing treatment system?	Yes
○ If yes, what system is responsible?	Landfill
• IMPACT ON SOIL AND WATER	
○ What is the current quality of the water?	Fair
○ How is the legislation regarding water?	Very strict
○ Are there problems of water because of the existing treatment system?	No
○ If yes, what system is responsible?	-
○ How is the legislation regarding soil contamination?	Strict
○ Are there problems of soil contamination associated with the existing treatment system?	Yes
○ If yes, what system is responsible?	Landfill
9. HEALTH AND SAFETY CONSIDERATIONS	
• Has the community ever encountered health issues or problems related to waste?	Yes
• If yes, were the issues related to the waste treatment plant?	Yes
• If so, which system had the problem?	Landfill, composting
• Has the community ever encountered safety issues or problems related to waste such as accidental release of pollutant, explosion, fires, air pollution, water contamination, soil contamination, illness, death, or other?	Y
• If so, was the treatment plant responsible for the safety issue?	Y
• If yes, which system was involved?	Landfill
10. DISPOSAL OPTIONS	

• COMPOSTING	
○ Is composting an option in the community's MSW management plan?	Y
○ Would a compost plant be acceptable by community members?	Highly acceptable
○ Is there a market demand for compost?	Y
• ANAEROBIC DIGESTION	
○ Is anaerobic digestion an option in the community's MSW management plan?	Y
○ Would an anaerobic digestion plant be acceptable by community members?	Acceptable
○ Is there a market demand for compost?	Y
○ Should the system include an energy recovery system (heat, steam)?	Possibly
○ Should the system include an electricity-generating device?	Possibly
○ Does the local legislation allow the sale of electricity from small producers?	Y
○ Is there a demand for more electricity within the community?	No
• INCINERATION	
○ Is incineration an option in the community's MSW management plan?	Possibly
○ Would an incineration plant be acceptable by community members?	Difficult to accept
○ What level of efficiency is required for the air emission control system?	According to international standards
○ Should the system include an energy recovery system (heat, steam)?	Y
○ Are there industries in proximity that could buy the steam produced?	Possibly
○ Should the system include an electricity-generating device?	Possibly
○ Does the local legislation allow the sale of electricity from small producers?	Y
○ Is there a demand for more electricity within the community?	No
• NON-COMBUSTION SYSTEMS PYROLYSIS - THERMOLYSIS - GASIFICATION	
○ Is a non-combustion system such as pyrolysis, thermolysis or gasification an option in the community's MSW management plant?	Y
○ Would a non-combustion plant be acceptable by community members?	Highly acceptable
○ Should the system include a resource recovery system	Y

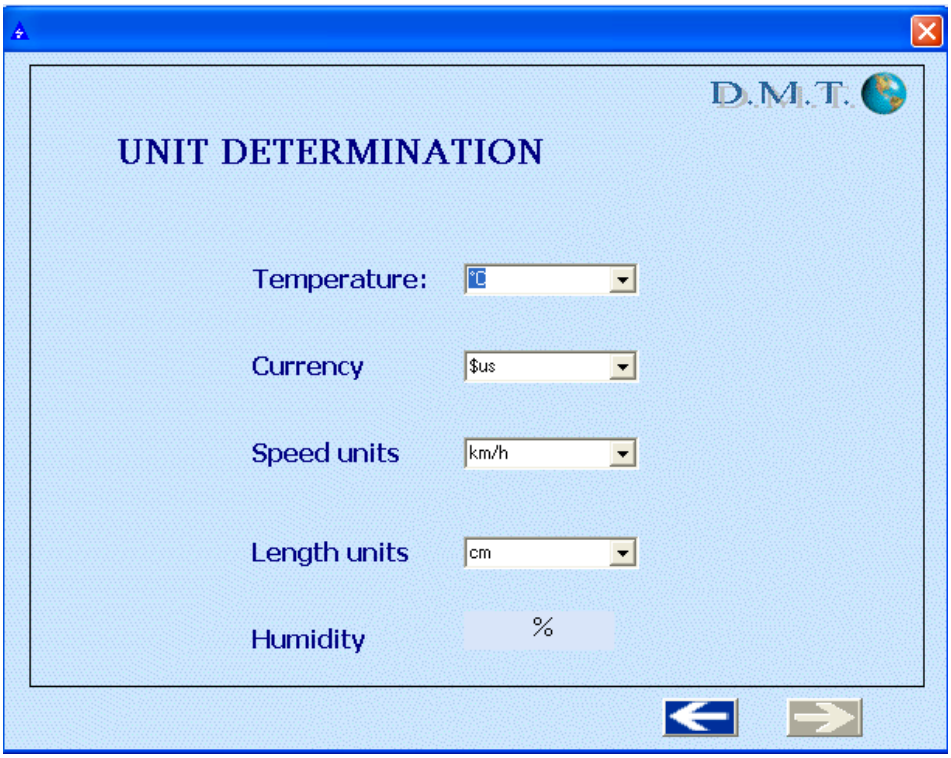
(i.e. carbon, oil, heat, steam)?	
○ Are there industries in proximity that could buy the steam produced?	Possibly
○ Should the system include an energy production device?	Possibly
○ Does the local legislation allow the sale of electricity from small producers?	Y
○ Is there a demand for more electricity within the community?	No
• LANDFILL	
○ Is land filling an option in the community's MSW management plant?	Y
○ Would a landfill be acceptable by community members?	Acceptable
○ Does the community require a new landfill?	N
○ Can the existing landfill continue to be used?	Y
○ Should the landfill gas be recovered?	Possibly
○ Should the system include an electricity-generating device?	Possibly
○ Does the local legislation allow the sale of electricity from small producers?	Y
○ Is there a demand for more electricity within the community?	No
• WASTE TO ENERGY	
○ Is a waste to energy system an option in you MSW management plant?	No
○ Would a waste to energy plant be acceptable by community members?	Acceptable
○ In case of non-combustion, should the system include a resource production system (i.e. carbon, oil, heat, steam)?	Possibly
○ Does the local legislation allow the sale of electricity from small producers?	Y
○ Is there a demand for more electricity within the community?	No

6.4 THE DECISION MAKING TOOL APPLIED TO BANGKOK

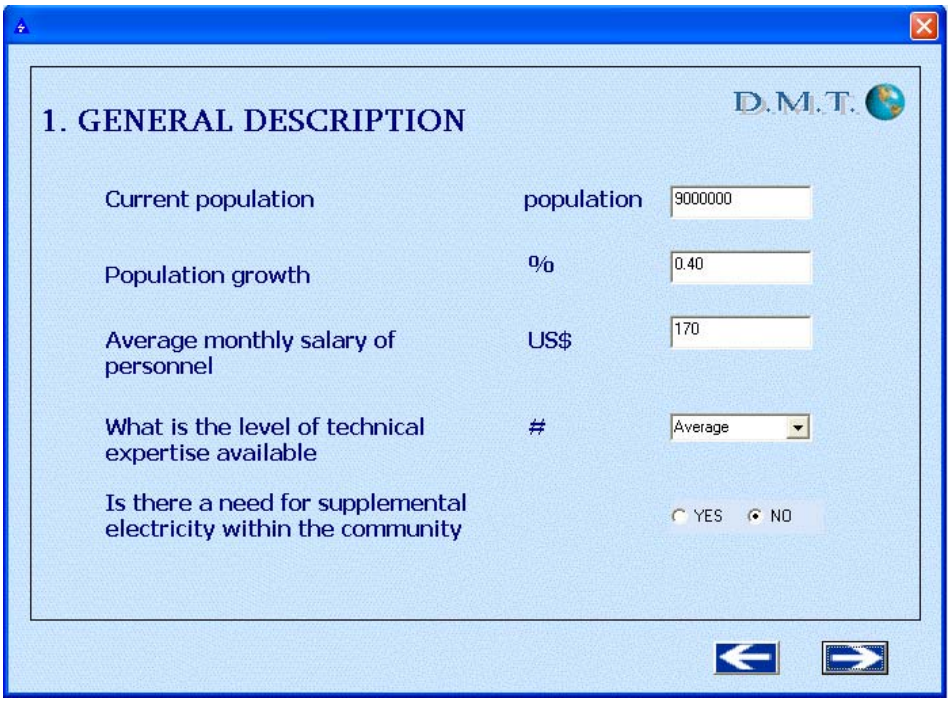
The following shows the slides with the questions of the decision-making tool (DMT), as applied to the municipality of Bangkok.

Title frame introducing the progamme

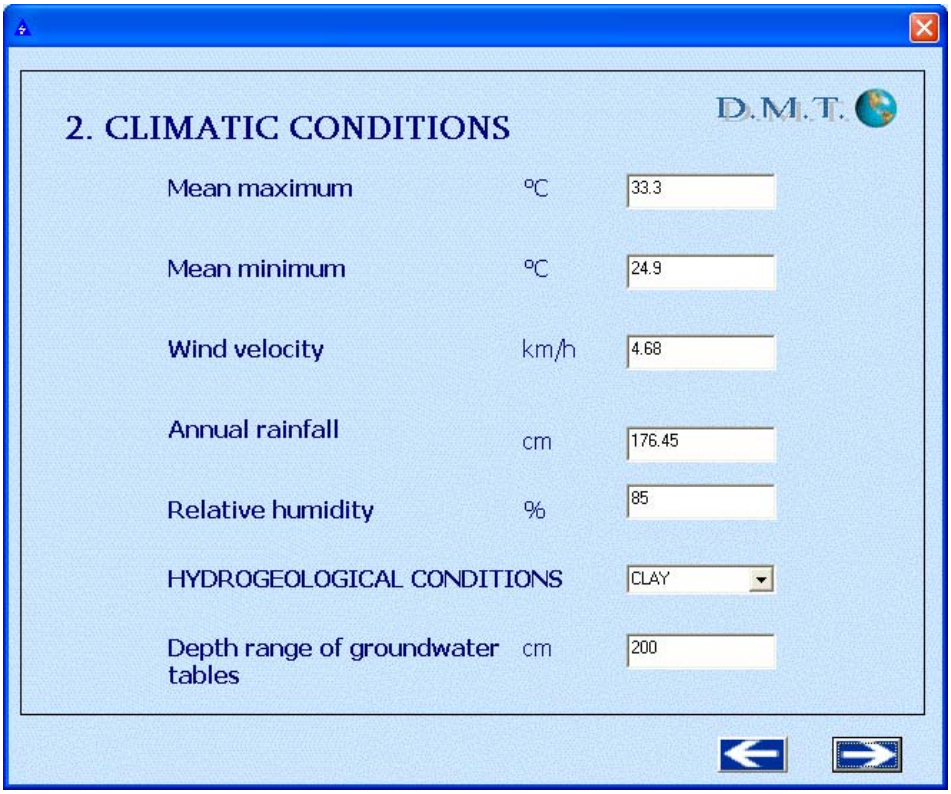
The unit determination here confirms the use of metrics and US$, units which are to be used for all of the data entries.



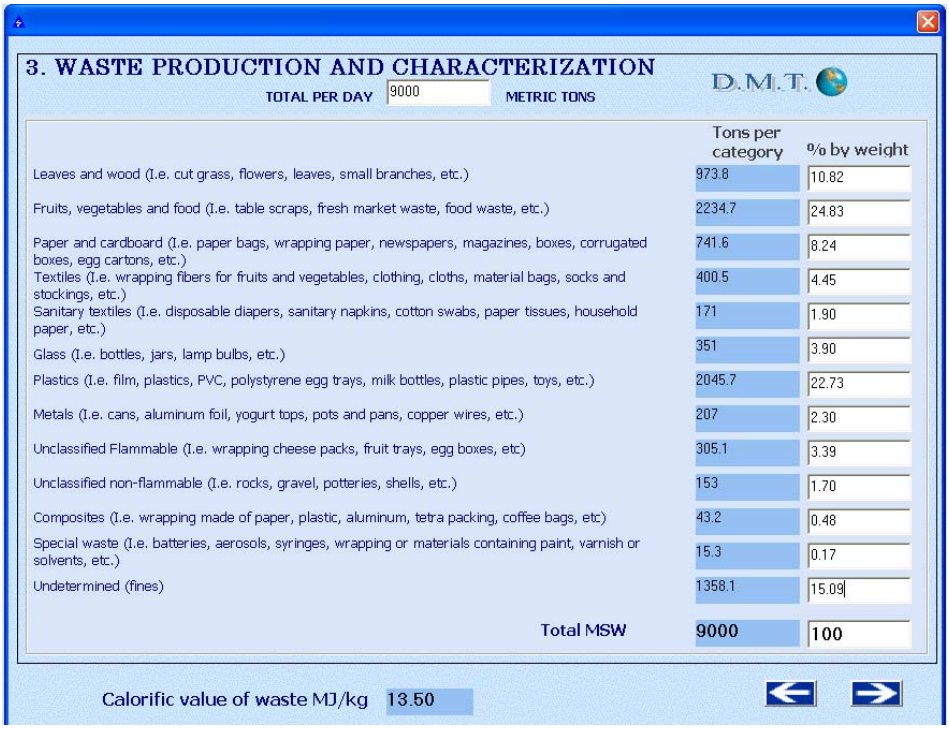
The general description gives the population of Bangkok, the population growth at the moment of the data entries, the average salary per month countrywide.



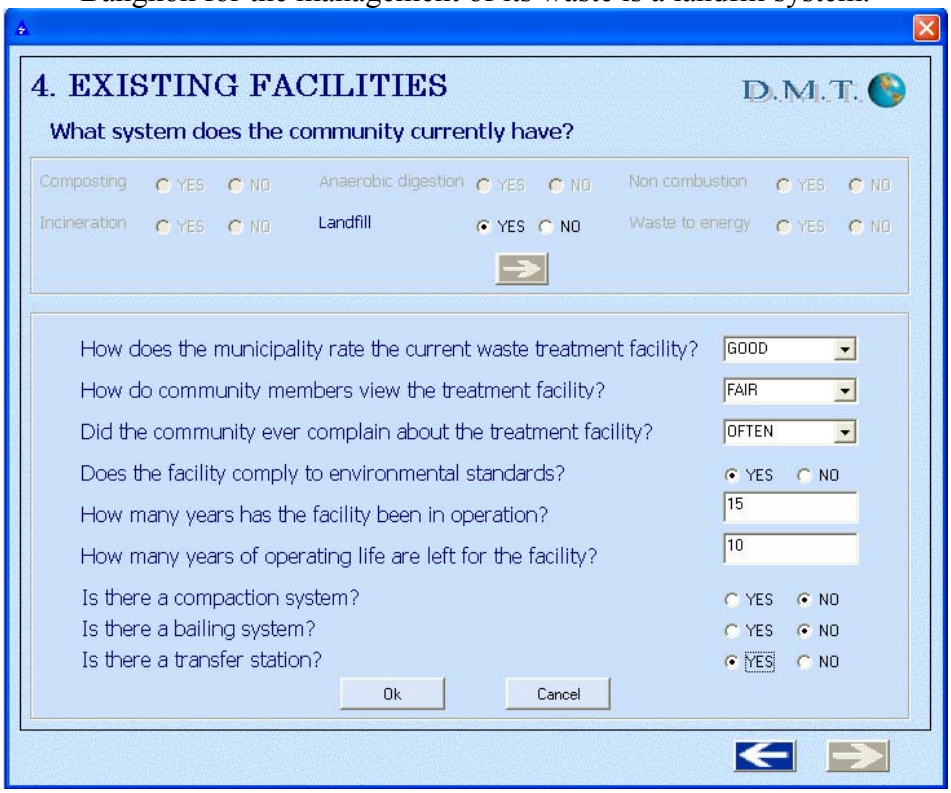
Climatic conditions here show the warm and humid climate that is Thailand, as a tropical Asian country.



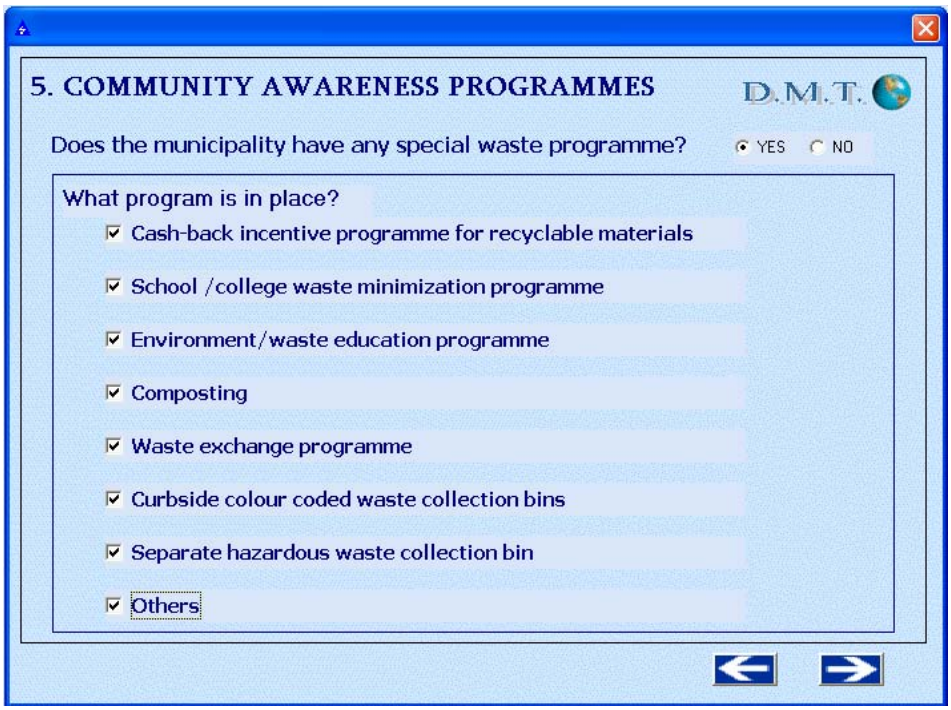
The quantity of waste is based on the data collected. Here the data shows 9000 tonnes per day of waste collected within the municipality. A waste characterization was conducted and the results are shown in the breakdown of the waste. The calorific value of the waste was calculated with the calculator developed based on theoretic values. In reality, it may vary slightly depending on the level of humidity found in the waste.



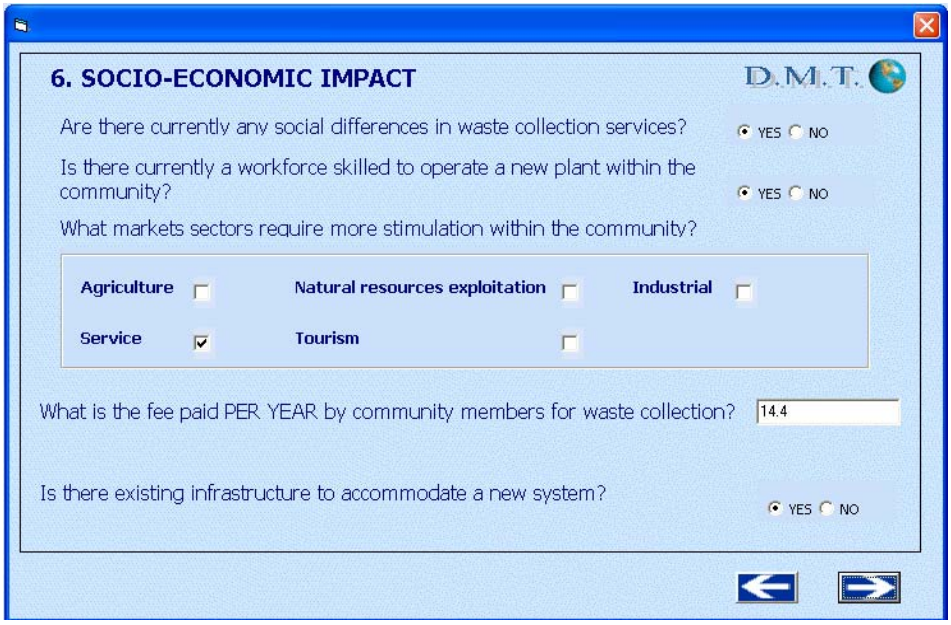
The review of existing facilities shows that at present, the only system utilized in Bangkok for the management of its waste is a landfill system.



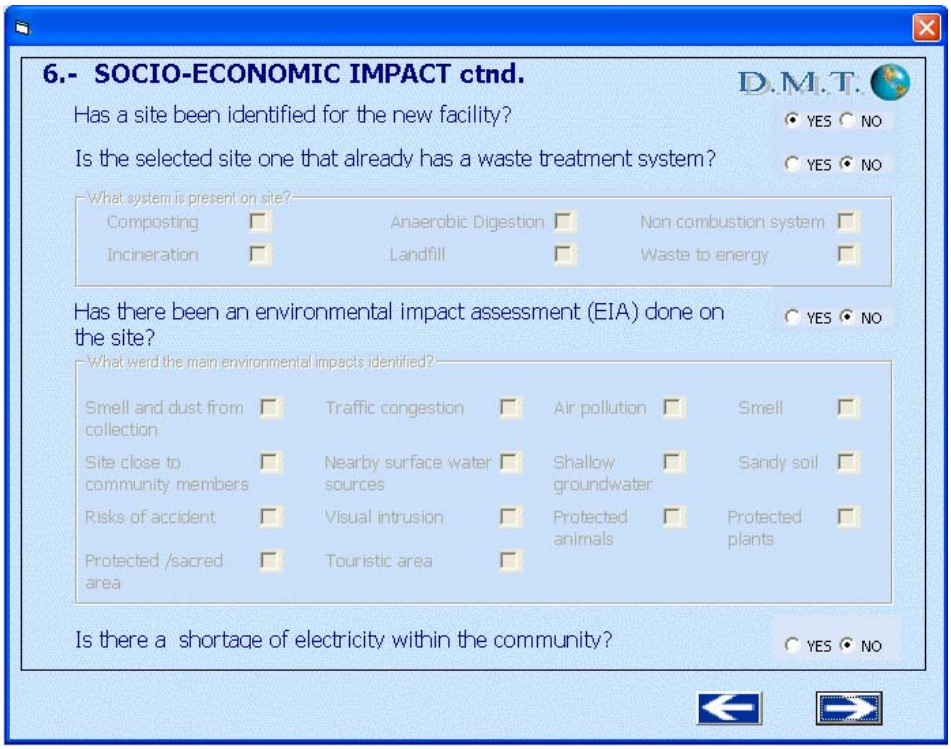
Here one can verify the efforts of the local government in developing various waste programmes. Bangkok has several programmes in place with the objective of sensitizing its population in the need for waste reduction.



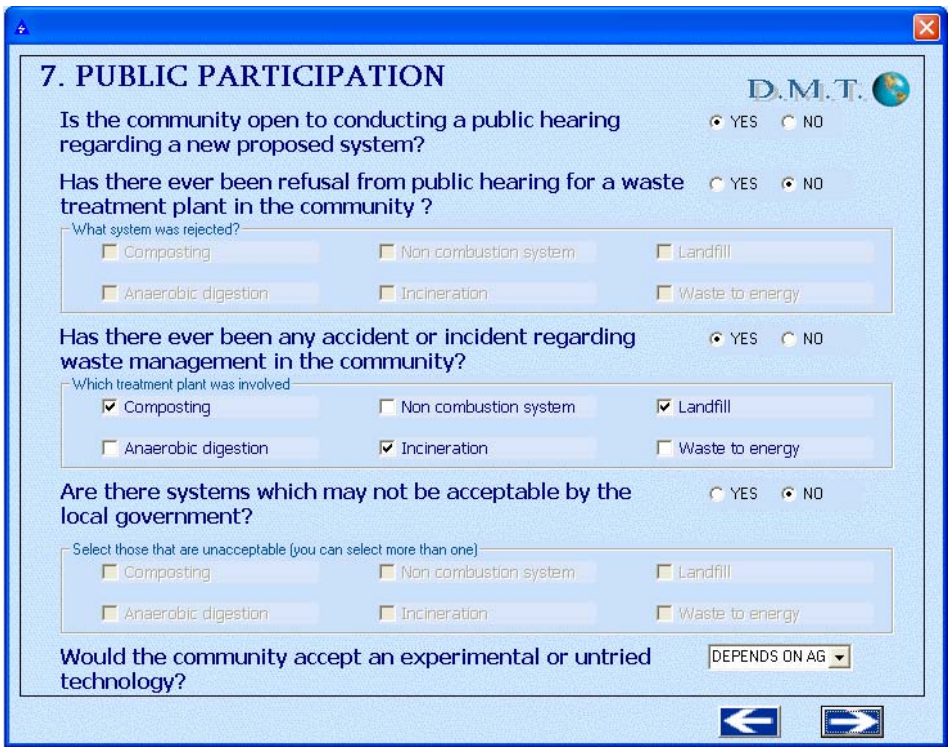
The social impact of the system is determinant on its implementation and smooth operation. Bangkok's service industry is in need of stimulation and this is reflected in the following frame Moreover, the amount of money paid for collection fees also shows the difficulty in implementing a high-Tec system such as waste to energy.



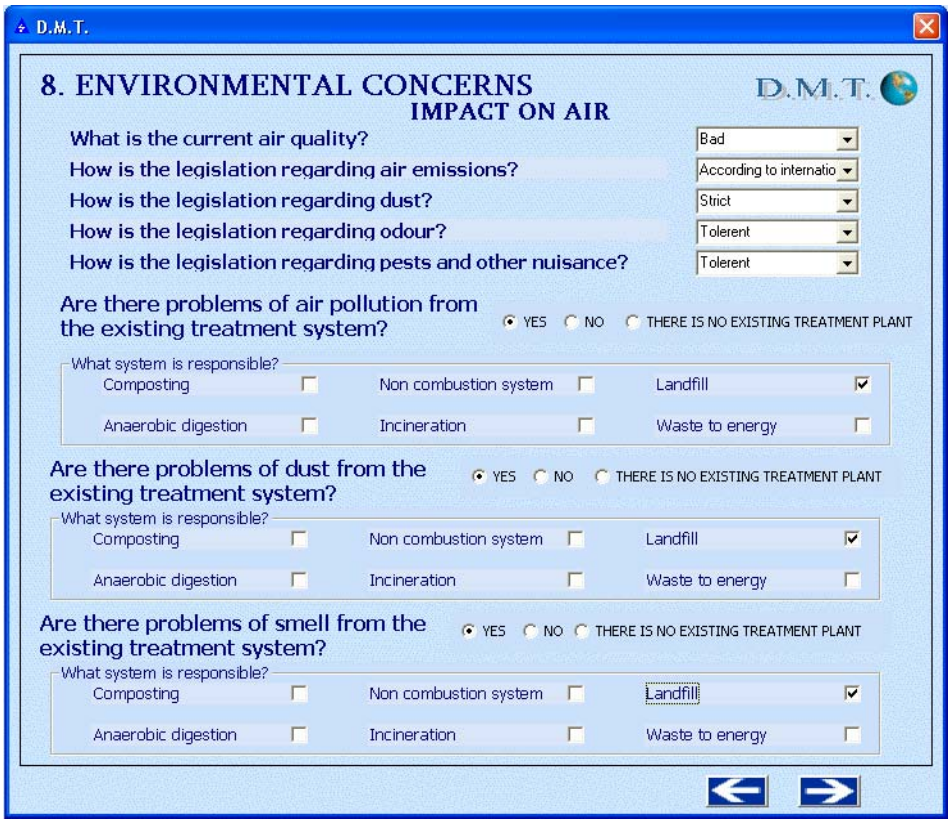
Environmental impacts are required in Bangkok but in this case, although a site has been selected, no EIA has been conducted.



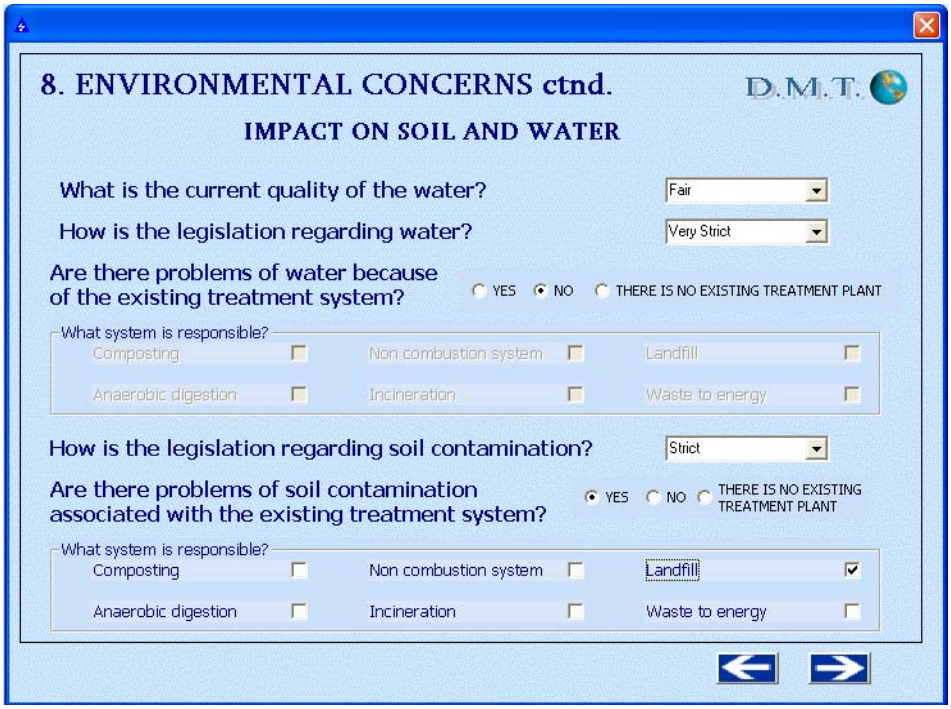
Public hearings in Bangkok are complex and often extremely negative experiences. Therefore, information on public participation is crucial in the good selection of an appropriate MSWM treatment system.



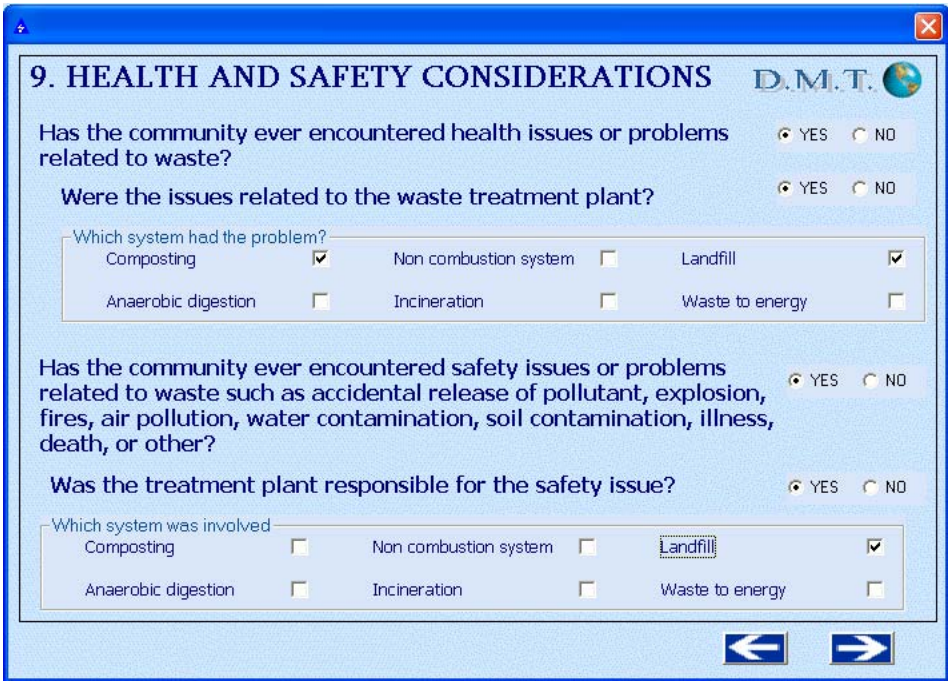
Environmental impacts on air, water and soil are increasingly stringent in Bangkok. Therefore, a review of the current condition and of existing problems will allow decision makers become more aware of the needs of appropriate technologies



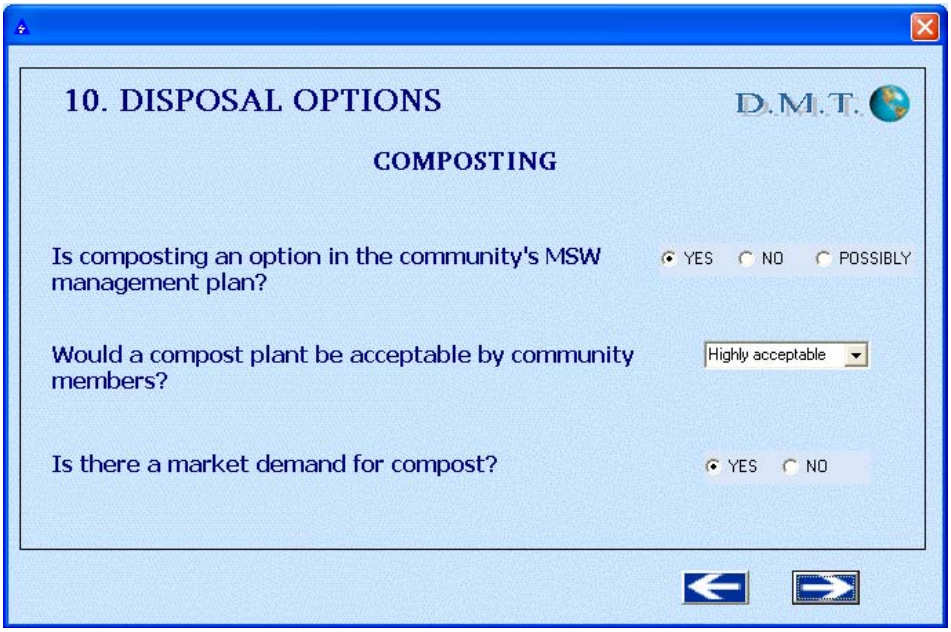
Industries are now required to treat all wastewater and chemical waste as to avoid soil and water contamination. The laws are now also applied for municipalities.



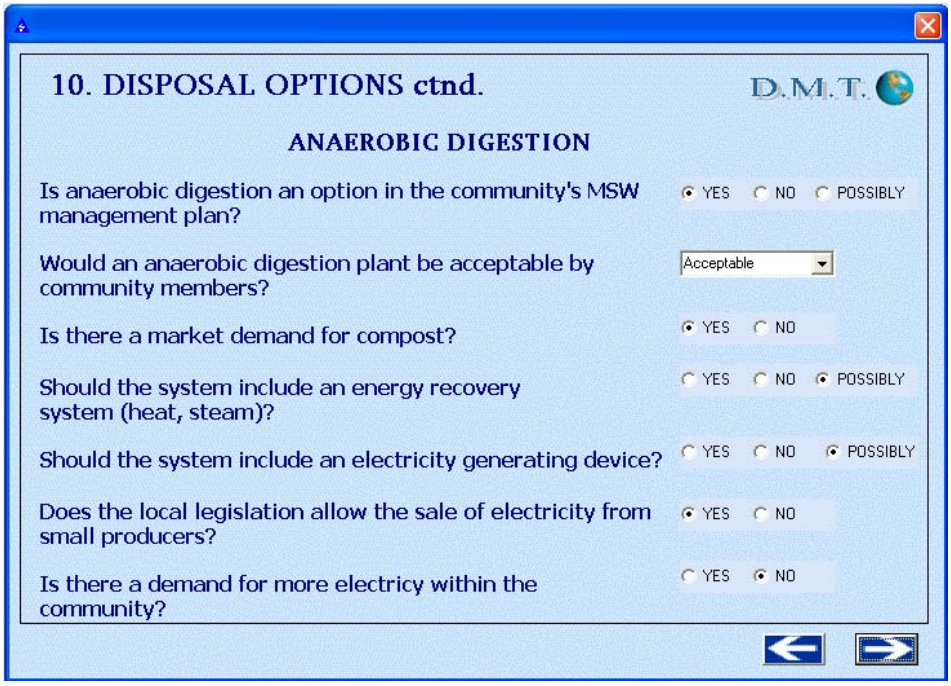
One of the responsibilities of local communities is the protection of its population. Therefore, health and safety should be priorities for decision makers. A review of past problems not only creates awareness to decision makers but also can help avoid future similar problems.



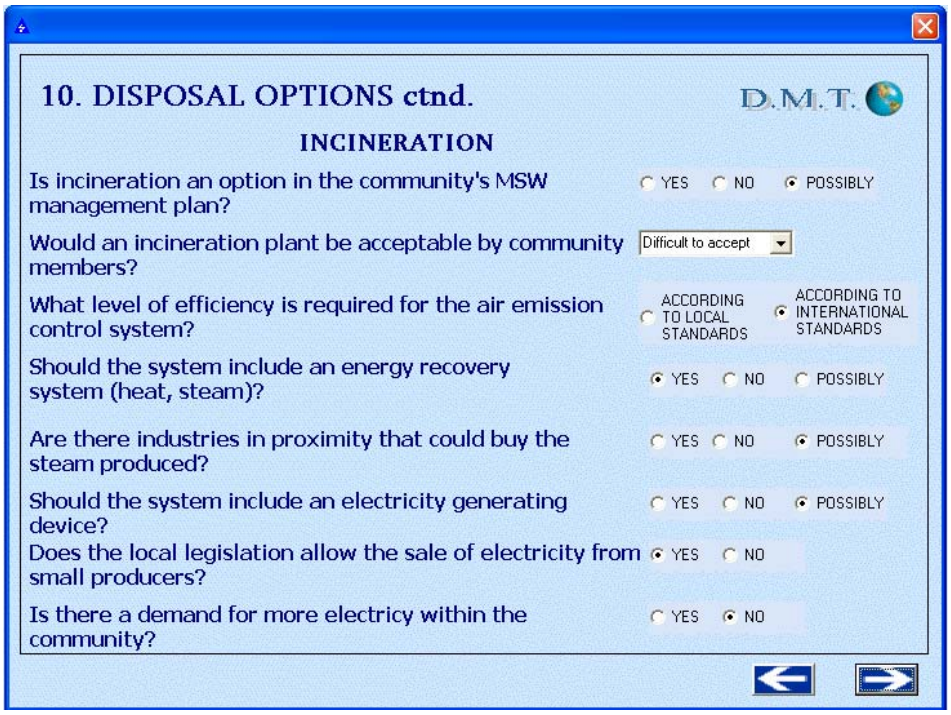
Disposal options are helpful to approach various possibilities of disposal in a more objective manner. For example, if there were no market for compost, there would be no need to establish a compost plant.



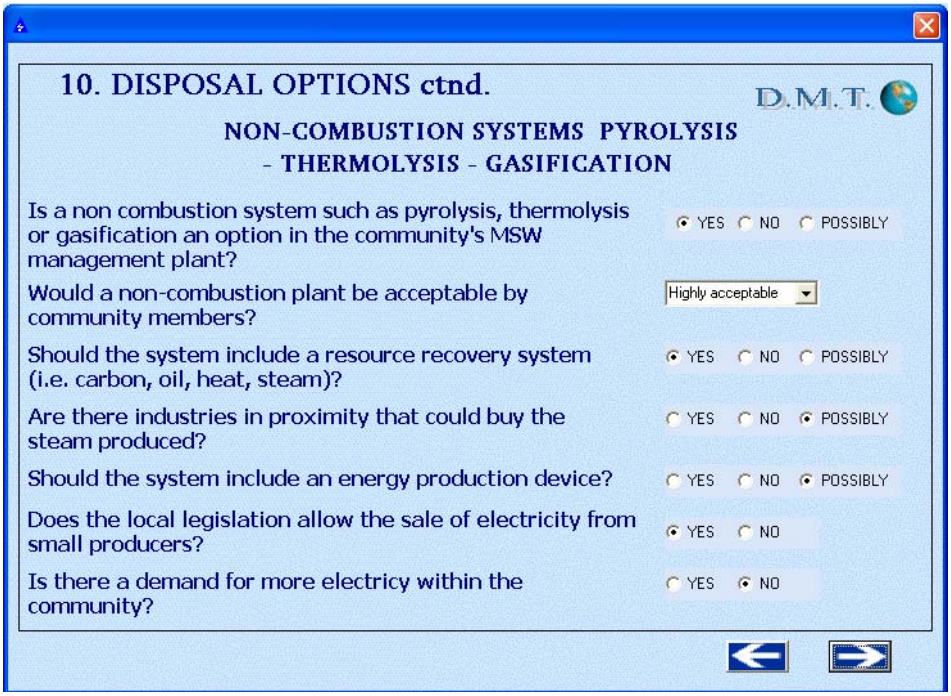
In the same way, an anaerobic digestion system is useful when there is need for compost and for supplemental energy. If no markets are available, the system may not be feasible.



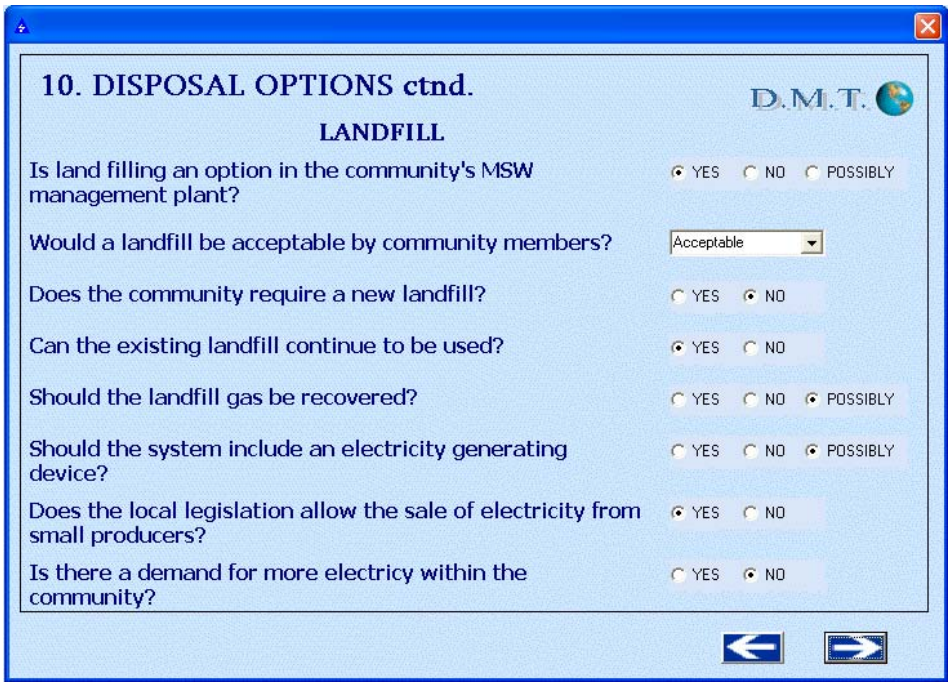
Incineration in one of the options that was considered by the municipality but not very appreciated by its population. Moreover, the operating costs associated with the incineration project required that the municipal government increase the monthly fees associated with waste collection. Therefore, the initial project was rejected.



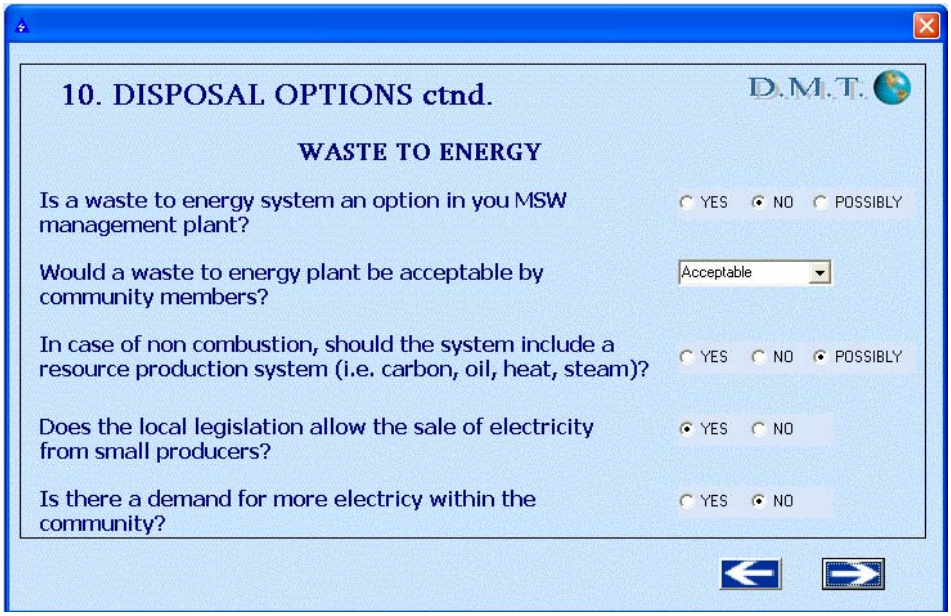
Non-combustion systems were promoted in Thailand and the community started to see some of the advantages of the system. A study market would however be required in order to verify the market outputs for resource recovery products.



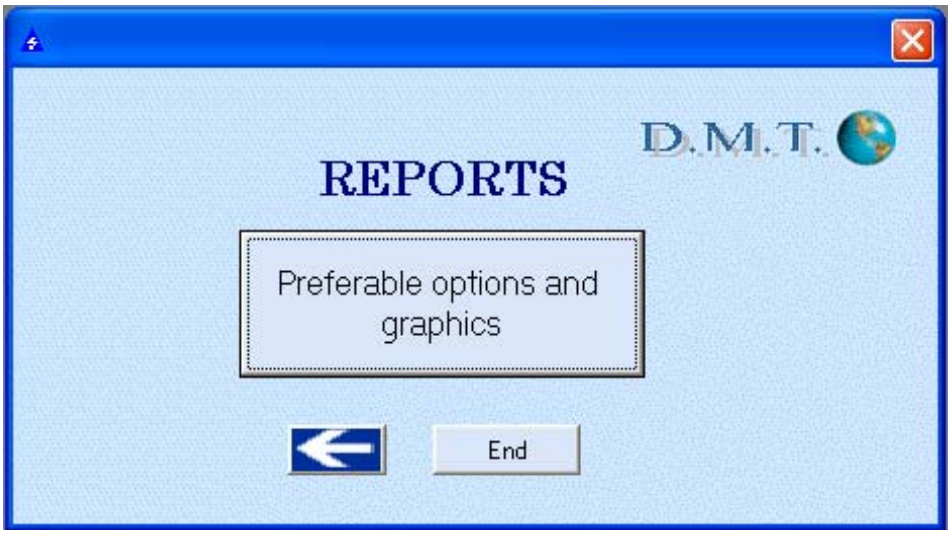
Landfill has been the main and currently, the only waste disposal system in Bangkok. It is acceptable by the local population because it has been utilized for such a long time.



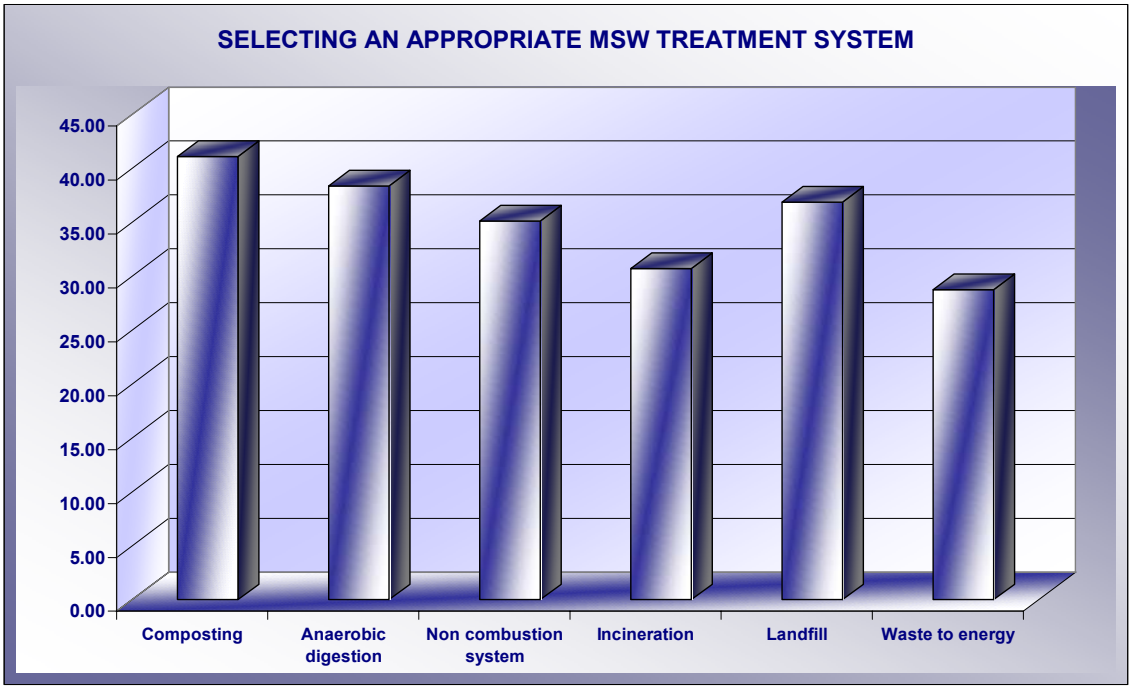
Waste to energy systems are associated with high costs. Moreover, Bangkok currently is not in need of supplemental energy and therefore the system may not be feasible.



Following the list of questions, reports on preferable options and graphics are generated automatically.



The initial frame shows the various options as per the scoring calculated based on the answered questions. Here, composting remains a preferred method of disposal followed by anaerobic. Although there is no need for supplemental energy production, the Thai government still offers incentives to small energy producers, which could be that of an anaerobic digester.



Frame 11 gives the details of the accumulated values for each of the MSW treatment system, values which were represented in the graphic above.

11. WASTE DISPOSAL SCENARIO ANALYSIS

ANALYSIS	Composting	Anaerobic digestion	Non combustion system	Incineration	Landfill	Waste to energy
1. GENERAL DESCRIPTION	5.00	2.50	2.50	2.50	4.10	2.50
2. CLIMATIC CONDITIONS	4.00	4.00	3.00	3.00	2.00	3.00
3. WASTE PRODUCTION AND CHARACTERIZATION	1.50	1.50	1.50	1.50	1.50	1.50
4. EXISTING FACILITIES REVIEW	0.00	0.00	0.00	0.00	4.50	0.00
5. COMMUNITY PROGRAMMES	7.00	7.00	6.00	3.00	7.00	3.00
6. SOCIO-ECONOMIC IMPACT	6.00	3.00	3.00	3.00	4.00	3.00
7. PUBLIC PARTICIPATION	3.50	4.50	4.50	3.50	3.50	4.50
8. ENVIRONMENTAL CONCERNS	8.75	8.75	7.25	7.25	4.75	7.25
9. HEALTH AND SAFETY CONSIDERATIONS	1.00	2.00	2.00	2.00	0.00	2.00
10. DISPOSAL OPTIONS	2.75	4.50	4.75	3.75	3.50	2.00
DISPOSAL ANALYSIS	41.10	38.35	35.10	30.70	36.85	28.75

THE HIGHER THE NUMBER THE MOST APPROPRIATE THE SYSTEM

The decision maker is then allowed to evaluate various case scenarios to verify the most appropriate integrated MSWM treatment system. One can see below that Bangkok

community objectives appear to be justified as the preferred scenario compared to the other three alternatives. Here, the community objective emphasizes the use of anaerobic digestion while alternative scenario 1. stresses non-combustion systems, scenario 2. incineration and scenario 3. waste to energy systems.

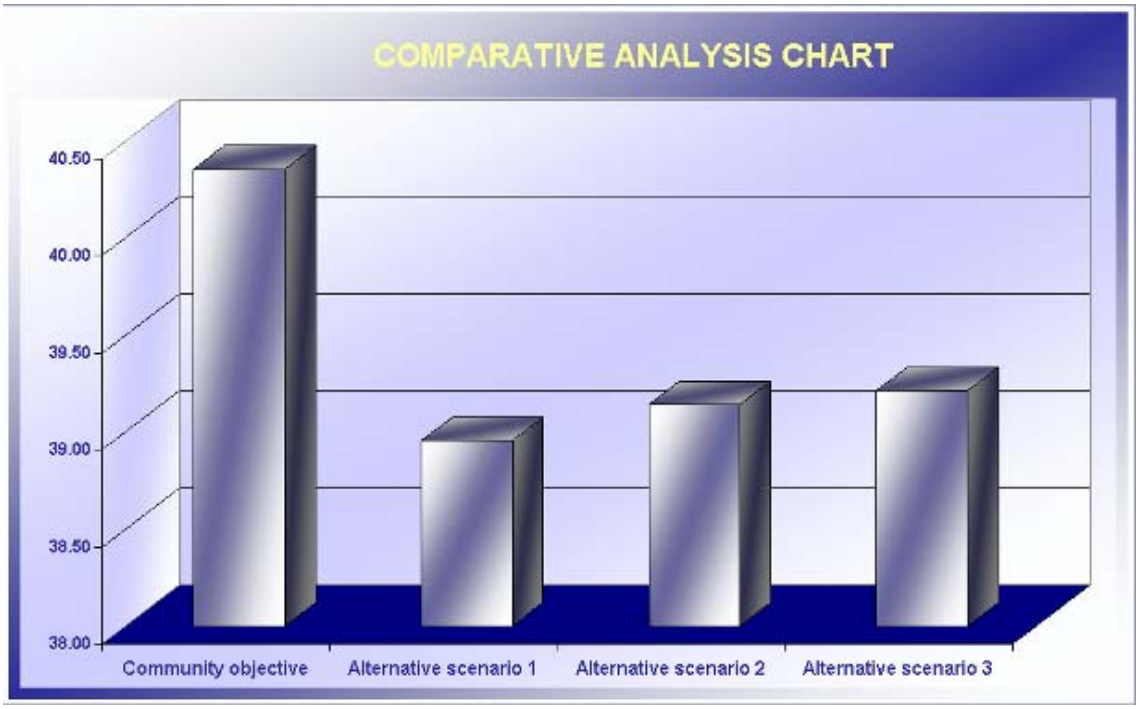
12. COMPARATIVE ANALYSIS FOR FOUR INTEGRATED WASTE TREATMENT SCENARIOS

	Community objective	Alternative scenario 1	Alternative scenario 2	Alternative scenario 3
Recycling	20%	20%	25%	30%
Composting	10%	0%	20%	20%
Anaerobic digestion	30%	0%	0%	0%
Non combustion	0%	30%	0%	0%
Incineration	0%	0%	30%	0%
Landfill	40%	50%	25%	20%
Waste to energy	0%	0%	0%	30%
TOTAL	100%	100%	100%	100%
Analysis SCORE	40.35	38.95	39.14	39.21

Enter values in yellow to verify various alternative scenarios

Analysis result: The higher the score, the better the option.

The results from Frame 12 are presented in a graphic form.



Decision makers can then select a 15-year MSWM plan to be developed on a five-year implementation base. Below, the chart uses the values selected for the community objectives followed by the three case scenarios from Frame 12, as seen in the blue column. The decision maker can then evaluate various combinations of MSWM treatment systems towards the selection of the most appropriate system. The DMT calculates waste generation increase over fifteen years based on the percentage of population growth registered in frame 1.

13. FIFTEEN YEARS WASTE MANAGEMENT PLANNING; COMPARING FOUR CASE SCENARIOS

Enter values in yellow section to compare four case scenarios over the next 15 years

Community objectives

Total waste to be treated Year 1 : 9000.00

SCORES

The higher the score, the better the option

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	20%	1800.00	30%	2754.43	30%	2809.96	40%	3822.15
Composting	10%	900.00	20%	1836.29	20%	1873.31	20%	1911.08
Anaerobic digestion	30%	2700.00	30%	2754.43	30%	2809.96	30%	2866.62
Non combustion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Incineration	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Landfill	40%	3600.00	20%	1836.29	20%	1873.31	10%	955.54
Waste to energy	0%	0.00	0%	0.00	0%	0.00	0%	0.00
TOTAL (total must be 100%)	100%	9000.00	100%	9181.45	100%	9366.55	100%	9555.39

Community objectives analysis result 167.14

Alternative scenario 1

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	20%	1800.00	30%	2754.43	30%	2809.96	40%	3822.15
Composting	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Anaerobic digestion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Non combustion	30%	2700.00	30%	2754.43	30%	2809.96	30%	2866.62
Incineration	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Landfill	50%	4500.00	40%	3672.58	40%	3746.62	30%	2866.62
Waste to energy	0%	0.00	0%	0.00	0%	0.00	0%	0.00
TOTAL (total must be 100%)	100%	9000.00	100%	9181.45	100%	9366.55	100%	9555.39

Alternative scenario 1 analysis result 161.08

Alternative scenario 2

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	25%	2250.00	25%	2295.36	25%	2341.64	35%	3344.38
Composting	20%	1800.00	30%	2754.43	30%	2809.96	30%	2866.62
Anaerobic digestion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Non combustion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Incineration	30%	2700.00	30%	2754.43	30%	2809.96	30%	2866.62
Landfill	25%	2250.00	15%	1377.22	15%	1404.98	5%	477.77
Waste to energy	0%	0.00	0%	0.00	0%	0.00	0%	0.00
TOTAL (total must be 100%)	100%	9000.00	100%	9181.45	100%	9366.55	100%	9555.39

Alternative scenario 2 analysis result 148.10

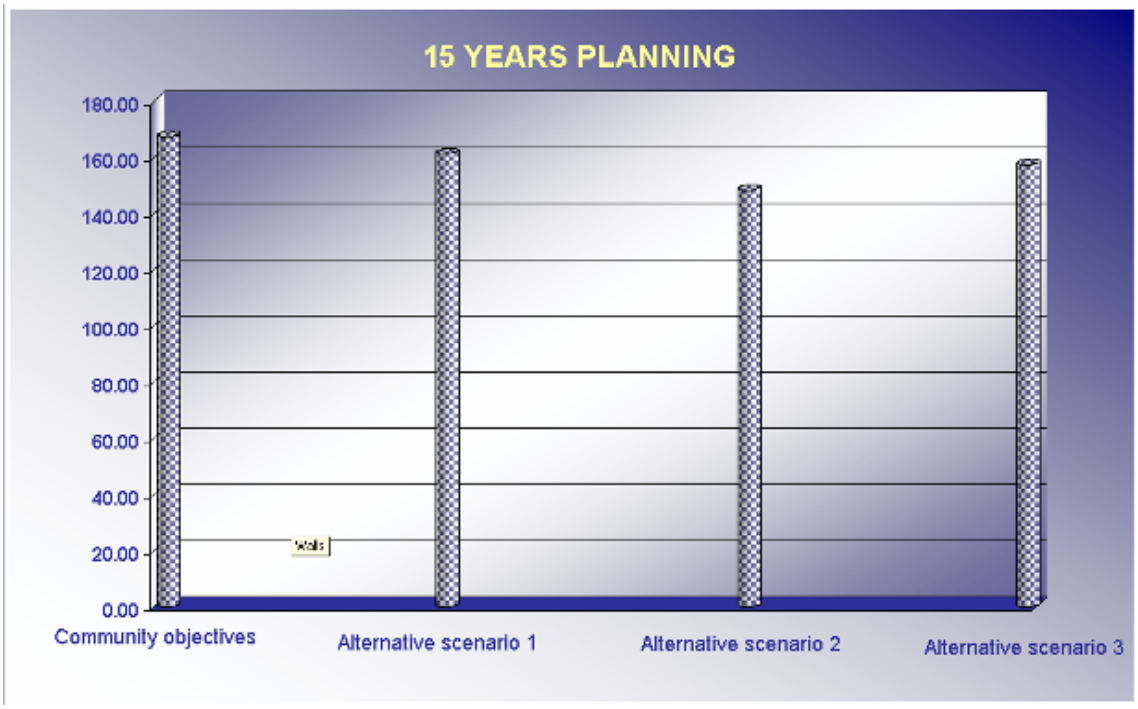
Alternative scenario 3

YEAR	2007		2012		2017		2022	
Quantity of waste processed	%	T/D	%	T/D	%	T/D	%	T/D
Recycling	30%	2700.00	30%	2754.43	35%	3278.29	35%	3344.38
Composting	20%	1800.00	20%	1836.29	30%	2809.96	30%	2866.62
Anaerobic digestion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Non combustion	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Incineration	0%	0.00	0%	0.00	0%	0.00	0%	0.00
Landfill	20%	1800.00	20%	1836.29	5%	468.33	5%	477.77
Waste to energy	30%	2700.00	30%	2754.43	30%	2809.96	30%	2866.62
TOTAL (total must be 100%)	100%	9000.00	100%	9181.45	100%	9366.55	100%	9555.39

Alternative scenario 3 analysis result 157.18

The final chart graphically shows that the community objective is the most appropriate integrated MSWM treatment system, followed by alternative scenario 1.

Following these results, a detailed feasibility study will be required on the selected case scenario or on a few of the potential case scenarios, thus reducing the study costs for the municipality, and facilitating the acceptance of the treatment system by community members.



6.5 SECTION SUMMARY

The decision-making tool consists of over one hundred closed-ended questions, which aim at analyzing the needs and current situation of waste management in a specific community, with the aim of selecting an appropriate MSWM system for this municipality. These questions were designed based on a decision-making framework. The decision-making tool is self-pondering, while offering flexibility to decision-makers as to the percentage of waste to be recycled, composted or to be treated by any of the six treatment system options.

Data collected and presented in chapter IV were entered into the decision-making tool as to verify the workability of the tool. All aspects that were determined necessary for a preliminary decision on MSWM, were entered into the decision-making framework and used in the decision-making tool through a series of closed-ended questions, as seen in the slides of the decision-making tool, section 6.3. Testing of the tool was conducted with the data of the municipality of Bangkok, as entered into the frames.

The results of the decision-making tool were then compared to those found during the Waste Management Study for the city of Bangkok. Findings proved to be similar to the results presented by the engineering team of the Bangkok study. This confirms that the tool can be used as a preliminary review of MSW treatment system options by various municipalities.

7. Summary and conclusions

7.1 MSW MANAGEMENT

MSW management is a costly yet necessary activity as to ensure the welfare of both people and the environment. It is estimated that by the year 2025, Asia will need to spend about US$ 47 billion to manage and treat the 0.5 to 1 kg of MSW per person per day produced, with the cost of collection requiring more than 70% of this expenditure. From these numbers, one can estimate the cost of MSW management in developing countries to be approximately US$ 5.00 per capita per year. Financing strategies need to be developed by municipalities to help alleviate the costs associated with waste management. In developing countries, numerous people cannot afford to pay high prices for waste management and therefore it is the responsibility of the government to manage and finance MSW management as to protect the people, the community, and the environment.

Unfortunately, MSW management is often not a priority for governments in emerging and developing countries. Focus is given to infrastructure, social services and industrial development, until someone notices the deteriorating environment. Emergency measures then need to be taken, often-leading decision-makers to the selection of an inappropriate MSWM system. Moreover, clean-up costs will often be required, especially in cases where industries have been allowed to dump their waste without restrictions or law enforcement. Health hazards, contamination and poor sanitation are all associated with the absence of waste management. Wild unsecured landfills are the perfect breeding grounds for pests, rodents and disease. Especially in hot and humid environments, the problem increases exponentially, according to the humidity and temperature levels.

The objectives of the municipality remain crucial and key factors in the decision-making process. The quantity of materials recycled, the usability of compost, the interest for anaerobic digestion, the possibility of incineration, the understanding of a non-combustion system, the availability of land for landfill, and the need for electricity, are some the key factors that need to be considered.

Moreover, recycling is a critical issue in developing countries where a large number of people depend on recycling for survival. Formal sorting can be undertaken by municipal workers while non-formal sorting is the main income generating activity for thousands of people around Asia. The impact of recycling can also be seen on the calorific value of waste, which may be detrimental to an incineration system while helpful for a composting plant. Sorting of waste, therefore, has a direct impact on the type of treatment used and its feasibility.

The location of the treatment plant is crucial to minimize environmental impact and community disturbance. The size of land available will also be determinant on the type of treatment plant. A landfill site would require much more space than an incineration plant. Various types of composting plants also require different sizes of land. Therefore, land availability plays a key role in treatment plant selection. Site characteristics are also important factors to be considered. Proximity to waterways, depth of groundwater and

type of soil are all factors that must be verified prior to the selection of a waste treatment plant's location as to ensure environmental protection.

Overall, alternative waste treatment options must be compared in terms of waste recovery, by-products produced such as gas, oil, heat, steam, and emissions such as wastewater and smoke, along with each of their advantages, disadvantages and risks. MSW treatment often generates some sort of solid residue such as ashes, slag and wastewater that will need be treated and landfilled. Depending on the local legislation, more or less treatment on these residues will be required.

7.2 MSW TREATMENT SYSTEMS, EQUIPMENT AND MANAGEMENT PROCEDURES

Common equipments

A weighbridge is necessary at the entrance of a waste treatment plant as to verify the tonnage of waste entering the plant. Lorries or garbage trucks will be weighed upon entering and at their exit once emptied, the difference of weight being the tonnage of waste dumped at the treatment site. Access to a wastewater treatment plant will be required to ensure the treatment of all liquors and excess water produced during treatment. Wastewater will also be produced during truck washing and site cleaning. This wastewater will also need to be sent to the wastewater treatment plant for processing prior to discharge.

Recycling:

Recycling of mixed materials can be a good source of income. Primary recycling is generally done prior to any waste treatment system. The type of waste to be separated must take into consideration the treatment selected. For example, high removal of paper, cardboard and plastic materials would severely lower the calorific value of the waste, rendering an incineration plant potentially uneconomical. However, if the waste is to enter a treatment plant which focuses on the transformation of organic matter into compost, then the removal of plastic would certainly be beneficial and a major contribution to the quality of compost.

Mechanical sorting may be an efficient method for waste segregation. However, in developing countries, labor costs are very low and therefore, manual sorting is often the preferred method. An increasing number of waste treatment plants are using a combined sorting method with gross sorting using trommels, followed by manual sorting. Then a magnetic separator can be used to separate ferrous materials. Density separators can also be used to further eliminate unwanted materials such as non-ferrous materials and glass.

Composting

Composting will allow the removal of organic waste and convert it into compost. This compost can then be utilized in the parks of the municipality or sold to generate income.

A composting plant will consist of a large waste reception hall, followed by a primary sorting and separation hall. A biofilter in the building is highly recommended due to the very strong smell of waste both in the reception hall and in the composting part. Various odor control systems using water and sometimes chemicals such as acid wash can be used. Biofilters made of activated carbon or other types of porous absorbing materials are also efficient odor removers.

Outputs from a compost plant include:

- Household waste
- Cellulose materials
- Water for wetting treatment (composting absorbs water)
- Residues form primary sorting
- Residues from refining
- Dry compost (approximately 50% dry matter)

Anaerobic digestion:

The main outputs from an anaerobic digestion system include the following:

- Biogas (which can be converted into electricity)
- Dry, refined compost
- Residues from primary sorting
- Residues from final refining
- Excess liquor that will need to be purified in a wastewater treatment plant (anaerobic digestion produces water)

The percentage of each of these outputs will be determined by the quantity and characteristics of the waste. The advantage of the anaerobic digestion system is its cogeneration heat recovery system, which emanates from the exhaust gases and the cooling of internal fluids. Therefore, heat, electricity and compost can be produced, recovered and sold.

Heat needs to be channeled to a nearby facility since it cannot travel long distances. Produced heat can be used by a nearby wastewater treatment plant for drying during the process of sludge dewatering.

Non-combustion systems

Non-combustion systems, although in existence for several decades, have not been used extensively for MSWM. Because of their thermal system, they are usually associated with incineration, which is often "*non-grata*" in municipalities. Often smaller in size, non-combustion systems cannot be easily used for large communities, unless several plants were to be connected to each other.

The main objective of the non-combustion system is to convert waste into by-products, which are usually carbon, oil, gas, steam and heat. These can be utilized, even refined, and used or sold as renewable energy products. The disadvantage of the system is that for large volumes of waste, about 20% of the initial volume remains. Therefore, a market to sell these by-products must be identified. The main advantage of this system is that it does not generate any emissions since all by-products are to be recovered and utilized or sold, and will become a source of income, contributing in the payback of the system.

Incineration

Although highly charged politically, incineration offers high waste volume reduction. The main problem associated with incineration is the emissions. However, with modern technology associated with high investment costs, contaminating emissions can be minimized if not totally eliminated.

The major outputs from incineration include:

- Gas
- Heat
- Residues from primary sorting
- Residues following incineration (ashes and slag)
- Residues from air pollution control system (solid and/or liquid – from scrubber)
- Air emissions

Air pollution control (APC) systems have become highly sophisticated and therefore an incineration plant remains an environmentally acceptable option if a proper APC control system is installed. Nevertheless, these systems are very expensive, costing up to 30% of the total investment cost of the incinerator itself. Because of the high costs associated with APC systems, municipalities often try to cut costs by installing a low-performing APC system. This implies the release into the atmosphere of pollutants from the incinerator plant that includes dioxins and furans, which are known to be carcinogenic.

Landfill

Landfill is used as a main waste management system and sometimes as a final step for the disposal of residual materials following another treatment. The difference is mainly in the characteristics of the waste to be landfilled. Regulations in some countries forbid the landfill of untreated waste. In developing countries, most of the waste is going directly to the landfill without treatment.

Proper and controlled landfill sites include protection for soil, groundwater, surface water and air. These protections include:

- Off site generated storm water diverters
- Geological barriers at landfill base with additional synthetic geomembranes and/or synthetic liners
- Leachate collection and treatment systems
- Landfill cover to minimize odor and at the end of the operation of the cell, to prevent further production of leachate
- Landfill produced biogas collection and treatment (conversion into fuel or electricity) or flaring to eliminate odor and minimize environmental impact associated with methane and CO_2 found in the landfill gas.

Waste to energy

Waste to energy remains one of the most interesting concepts in the treatment of MSW. To be able to convert rejected materials such as MSW into a useful product such as electricity, is one of the challenges for many scientists around the world. Waste has always been and will always be generated by human activity around the world. To convert this negative value into a positive value is by far, one of the most sensible approaches to waste management. However, technology today still requires high investment costs in the transformation of waste into energy. Increasing interest is on landfill gas, which can be recovered and processed through generators as to produce electricity. Incinerator plants can also be equipped with energy recovery systems. Non-.combustion systems along with anaerobic digesters also convert waste into energy. The problem remains the cost.

In developing and emerging countries, especially those in Asia with high populations, the industrial and social development is increasingly demanding more power. Waste offers an unlimited amount of raw materials that should be converted into energy. It is only a matter of money, and most likely, in the future, technology will offer a low-cost conversion system, adaptable for small communities as well as large cities.

7.3 WASTE COLLECTION AND DISPOSAL

Responsibilities for the collection and disposal of waste must be clearly defined. In some instances, private operators may charge a fee to collect and/or treat the waste. The institutional set-up and legal framework here are determinant.

The two most common management agreements are public ownership, where the government owns the waste treatment facilities and leases it out to an operator. The other is a BOT system, where as the private contractor **B**uilds the treatment facilities, **O**perates it for a number of years, and then Transfers it to the government. BOT is often recommended as to lighten the burden of initial investment costs, which are often difficult for most municipalities, especially in developing countries.

The contractor can then receive income from various sources.

- Tipping fee (paid by government and/or users per tonne of waste received)
- Sale of recyclable/recovered materials (sale to wholesalers or directly to recycling industries)
- Sale of energy; heat, steam, electricity if produced (sale to electricity utility company, when allowed by local legislation)

In order to protect the contract, a minimum tipping quantity of waste is generally agreed between the parties. This means that the tipping fee is payable for the quantity of waste brought to the treatment facility. In case the amount of waste is less than the agreed daily tonnage, the minimum amount agreed upon is payable. If the quantity is more, the tipping fee is paid for the total quantity brought to the facility.

Price revision is important and can be done periodically based on a price revision formula, or by periodically fixing the prices agreed by both parties. The latter offers more flexibility and transparency.

7.4 WASTE CHARACTERIZATION AND ITS IMPORTANCE

Waste characterization is necessary prior to making a decision on the MSWM system to be used. Both the quantity of waste and its characteristics are crucial in order to ensure the feasibility of a treatment system. The analysis of waste allows the calculation of the quantity of waste, the quality of waste, its level of humidity and calorific value. The differences in the types and quantities of waste will be determined by food habits, culture, and with the level of social and community development.

During characterization, waste is separated into specific categories, giving a breakdown in percentage of the type of waste found for each of the categories. These categories may vary depending on the waste characterization methodology used. Nevertheless, the categories should be similar to the following: Leaves and wood; Fruits vegetables and food; Paper and cardboard; Textiles; Glass; Plastics; Metals; Unclassified Flammable; Unclassified non-flammable; Composites; Special waste; Sanitary textiles and Fines.

A minimum quantity of waste should be sampled as to ensure the reliability of the collected data. These samples are then to be sorted and analyzed, giving an appropriate estimate of the waste's characteristics. The level of humidity will be determinant in the selection of the MSW treatment system. For example, in cases of high levels of humidity, incineration becomes costly requiring drying prior to incineration.

All municipalities should verify the quality of waste through waste characterization as to utilize the data collected in their environmental plan. Specific recycling programmes could be elaborated from the data, and the information collected would allow a more specific and realistic choice of an appropriate integrated MSW treatment system.

7.5 INCOME SOURCES TO MUNICIPALITIES

Municipalities have various sources of revenue that allow them to finance waste treatment plants. These include:

- Property taxes on developed and undeveloped land
- Local taxes on rents
- Fee fine
- Permits and service charge
- Tax on billposting
- Household waste removal fees (collection fee is limited to 40 Baht (US$ 1.2) per capita per month [Muttamara et al, 2004]
- Rental from BMA assets
- Income from public utilities

The most common payment system is from property taxes, or by a specific fees payable per household.

7.6 DECISION-MAKING FRAMEWORK AND ITS APPLICABILITY

Waste management in an Asian tropical country involves specific challenges that need to be addressed. Economical, technical and social criteria need to be fully understood as to capacitate government officials in the selection of the most appropriate MSW management system. Limited budgets, lack of public awareness and poor systems' management often cloud decision-makers in choosing what appears to be the best solution in the short term, but more costly over the years. Weather conditions and scarcity of land in proximity of the municipalities make waste management especially challenging. The decision-making framework is a basis for decision-makers, as to facilitate the understanding and identification of key issues necessary in the formulation of a sustainable urban waste management plan and in the selection of a technically, economically and socially appropriate MSW management system, especially for tropical climate countries.

7.7 THE DECISION-MAKING TOOL

The decision-making tool aims at facilitating the selection of an appropriate MSW treatment system, based on social, climatic and technical information. In its simplicity, it allows public administrators with little experience in waste management and in computer science, to analyze various options and case scenarios in a comparative manner. It further verifies various case scenarios and allows integrated MSW management options.

Integrated waste management is probably the most sensible manner to approach MSW management. The integrated approach allows flexibility of waste management techniques, and complementarity of each of them. This tool specifically looks at six treatment options, namely composting, anaerobic digestion, non-combustion systems such as thermolysis, pyrolysis and gasification, landfilling and waste to energy. It further takes into consideration recycling and allows a combination of hundreds of options for integrated waste management.

The tool has been tested with one of the most complex situation that could possibly be encountered, and that is the MSWM for the municipality of Bangkok. The complexity of the municipality comes from its high population, high-level humidity, high-density population and limited budget. Moreover, public awareness and public hearings have proven complex in the past. Therefore, the voice of the people is very strong in this locality and must be taken into consideration during the selection of a MSWM treatment system.

The decision-making tool has proven reliable and in compliance with the findings presented in the final report of the Waste Management Study for the Municipality of Bangkok, proving the workability of the tool. This tool can be used as a preliminary evaluation of the options on MSWM systems. In a second phase, the tool could be further developed as to include a cost-verification, and additional waste treatment systems that could be used in the management of MSW in developing countries.

Bibliography

1. Asian Development Bank Institute (ADBI), (1999) *Asian Cities, Introduction*, Japan, pp.1

2. Ademe (Agence de l'Environnement et Maîtrise de l'Energie - Agency for Environment and Energy Management of France, (1997) MODECOM Méthode de caractérisation des ordures ménagères, France, 62 pages.

3. Ademe (Agence de l'Environnement et Maîtrise de l'Energie - Agency for Environment and Energy Management of France, (1997) MODECOM et les collectes séparatives France, 48 pages.

4. Alpha Research Co., Ltd. (2004) *Pocket Thailand in Figures, 7th Edition, 2004,* Bangkok, Thailand, pp. 402.

5. Alpha Research Co., Ltd. (2000) *Thailand in Figures, 6th Edition, 2000-2001,* Bangkok, Thailand, pp. 944.

6. APE, (2001,) The current and potential use of urban organic waste in Karachi - A market analysis for composted municipal solid wastes, Unpublished Final Report, Association for Protection of the Environment (APE), Karachi, Pakistan.

7. Aravossis,K., Anagnostopoulos, P., Koungolos, Ath., Vliamos, S., (1999) A NEW METHODOLOGY APPROACH FOR THE TECHNICAL-ECONOMICAL EVALUATION OF ALTERNATIVE WASTE DISPOSAL METHODS BY USE OF MULTICRITERIA ANALYSIS, Land Planning & Regional Development Engineers Department University of Thessaly edition Areos, 383 34 Volos, Russia, 10 p.

8. Bakkes, J.A., Grosskurth, J. (ICIS), Indenburg, A.M., Rothman, D.S. (ICIS) and Van Vuuren, D.P., (2000) Description of selected global models for scenario studies on environmentally sustainable development, Global Dynamics and sustainable development programme GLOBO Report series No. 30, National Institute of Public Health and the Environment (RIVM), Netherlands, 55 pages.

9. Bangkok Metropolitan Administration, Department of Public Cleansing, planning and technical division, (1996) *Recycle Knowledge*, Thailand, pp.26.

10. Bangkok Metropolitan Administration, Department of Public Cleansing, (1997,) *Annual Report,* Thailand, pp. 89.

11. Bangkok Metropolitan Administration, Department of Public Cleansing, (1998) *Annual Report,* Thailand, pp. 210.

12. Bangkok Metropolitan Administration, Department of Public Cleansing, (1999) *Annual Report,* Thailand, pp. 76.

13. Bangkok Metropolitan Administration, Public Cleansing Department (1991 – 2000) *Internal and public reports*, Thailand.

14. Bangkok metropolitan Administration, (1999) *Public hearing report – Waste elimination project – ON NUCH*, Thailand, pp. 160.

15. Bank of Thailand, (1998) Annual Economics Report, Thailand.

16. Bank of Thailand, (1999) Annual Economics Report, Thailand.

17. Bank of Thailand, (2000) Annual Economics Report, Thailand.

18. Bank of Thailand, (20019 Annual Economics Report, Thailand.

19. Bidlingmaier, Werner, Professor Dr.-Ing.habil., (2003) Bauhaus Universität Weimar, Waste Management, Waste Management Master Plan, Introductory manual for a waste management master plan, Germany, 18 pages.

20. Billy, Woraphong, (1999) *Disposal of leachate by evaporation process*, Department of environmental Engineering, Faculty of Engineering, Chulalongkorn University, Thailand, pp. 219.

21. British Columbia Ministry of Water, Land and Air Protection, (1993) *Landfill criteria for municipal solid waste*, Government of Public Safety and Prevention initiatives Section, Environmental Protection Division, Canada, pp. 22.

22. Chongrungreong, Somsri, Ph.D. Assoc. Prof, (1999) *Study and design of a solid waste incinerator*, Thailand, pp. 137.

23. CIA, (2006) *World Fact Book*, USA,

24. College of Engineering, (1993) *Meeting on waste elimination technique by using incineration and landfill,* Chulalongkorn university in collaboration with Land and Country Planning Department of Ministry of Interior, Thailand, pp. 308.

25. COWI-EP & T Associates, (1999) *Capacity building and human resources development, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 63.

26. COWI-EP & T Associates, (2000) *Infectious waste management, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 22.

27. COWI-EP & T Associates, (2000) *Manual for route planning data collection, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 32.

28. COWI-EP & T Associates, (1999) *Mini workshop on 10th September 1999, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 17.

29. COWI-EP & T Associates, (1999) *Recommendations on Waste management planning system,* working paper, *Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 12.

30. COWI-EP & T Associates, (1999) *Report on workshop for district chiefs and other high-ranking BMA officers, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 30.

31. COWI-EP & T Associates, (2000) *Status report for the plot project in the Vadhana district, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 42.

32. COWI-EP & T Associates, (1999) *Strategic planning in BMA, Working paper, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 9.

33. COWI-EP & T Associates, (1999) *Summary of review of current status, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 16.

34. COWI-EP & T Associates, (1999) *Waste minimization aspects, Technical assistance to the Bangkok Metropolitan Administration: Improvement of solid waste Collection management*, Ministry of Environment and Energy, DANCED, Denmark, pp. 16.

35. Department of Mineral resources; Asian Institute of Technology, Division of water resources engineering (1982) *Groundwater resources in Bangkok area: Development and management study Comprehensive report 1978 – 1982, Research report No. 137*, Thailand, pp. 204.

36. Diaz, F. Luis, Savage, George M.; Eggerth, Linda L.; Golueke, Clarence G; (1996) Solid Waste Management for Economically Developing Countries. The International Solid Waste Association (ISWA). pp. 133 - 145

37. Environmental engineering Consultants, Ltd., (April 2000,) *Technical Assistance Employment Project to the Public Cleansing Department, Bangkok Metropolitan Administration, to support its solid waste management plan: On Nuch Plant development plan, Final report*, Thailand, pp. 62.

38. Environmental engineering Consultants, Ltd., (2000) *Technical Assistance Employment Project to the Public Cleansing Department, Bangkok Metropolitan Administration, to support its solid waste management plan: Tha Raeng Plant development plan, Final report*, Thailand, pp. 30.

39. Environmental engineering Consultants, Ltd., (2000) *Technical Assistance Employment Project to the Public Cleansing Department, Bangkok Metropolitan*

Administration, to support its solid waste management plan: Nong Khaem Plant development plan, Final report, Thailand, pp. 42.

40. Finland's Development Cooperation (1999) Evaluation and internal auditing research. Finland pp.1-3

41. FINPRO, (2004,) World Bank Financed Waste Management Projects: Overview of the Waste Management Markets and Trends in Developing Countries and Prospects for Finnish Companies, Project Advisory Services, Washington, USA, 18 p.

42. Goldstein, James Director, (2003) Sustainable Communities Group; Sieber,,Jack, Senior Software Scientist, WastePlan Software for Integrated Solid Waste Planning Version 5.0, Tellus Institute, Boston, MA. USA

43. Hämäläinen, Raimo P. and Alaja, Susanna, (2003) THE THREAT OF WEIGHTING BIASES IN ENVIRONMENTAL, DECISION ANALYSIS, Helsinki University of Technology, Systems Analysis Laboratory Research Reports, Finland, 33 p.

44. Hamid, Naved; Mehta, Dinesh; Millareal; Mildred, Ed. (2000) Asian Cities in the 21st Century; Contemporary Approaches to Municipal Management Volume IV Partnerships for Better Municipal Management Proceedings of a Forum in Colombo, 28 – 30 June 1999 .Asian Development bank Institute and Asian Development Bank Pub. Philippines, 208 pages p. 1

45. Hamner , Burton and Chiu, Anthony SF (2002) *The Philippine Clean Cities Project: Promoting Waste Minimization Through Local Government,* 4th Asia Pacific Roundtable for Cleaner Production, Yogyakarta, Indonesia, pp.7.

46. Hart, Doortje, (1996) *Composting of organic household waste*, WASTE – Netherlands, pp. 60.

47. Henry, J. Glynn and Heinke, Gary W., (1996) *Environmental Science and Engineering*, Prentice Hall International Editions, UK, pp. 778.

48. Hoornweg, D. and L. Thomas. (1999) "What A Waste: Solid Waste Management in Asia." Urban and Local Government Working Paper Series #1, Washington, DC. USA.

49. Japan International Cooperation Agency, (1999*) Country profile on Environment, Cambodia*, Japan, pp.37.

50. Japan International Cooperation Agency, (1991) *The study on Bangkok solid waste management,* Volume 1: Summary, Thailand, pp. 99.

51. Japan International Cooperation Agency, (March 1991,) *The study on Bangkok solid waste management,* Volume 2 Master Plan, Thailand, pp. 205.

52. Japan International Cooperation Agency, (March 1991,) *The study on Bangkok solid waste management,* Volume 3: Feasibility Study, Thailand, pp. 178.

53. Japan International Cooperation Agency, (1991) *The study on Bangkok solid waste management,* Volume 4; supporting report, Thailand, pp. 381.

54. Japan International Cooperation Agency; Department of Public Cleansing, Bangkok Metropolitan Administration, (1993) *Seminar on comprehensive solid waste management in Bangkok Metropolis,* Thailand, pp. 48.

55. Jayarishnan, Rajaraman, (1993) *Evaluation of groundwater quality and monitoring for Bangkok aquifer system*, Asian Institute of technology, Thailand, pp. 154.

56. Jeamteerasakul, Somchai, (1987) *Production of methane gas from solid waste by a two-stage anaerobic process,* Department of Sanitary engineering, Chulalongkorn University, Thailand, pp. 182.

57. Kazi, N. M., (1999) Capacity Building for Primary Collection in Solid Waste - Citizens Guide for Dhaka, Environment and Development Associates (EDA) and Water, Engineering and Development Centre (WEDC), Dhaka, Bangladesh.

58. Kim, Seung-Mok, (1995) *Demand and supply of waste derived compost in Bangkok Metropolitan Region*, Asian Institute of Technology, Thailand, pp. 144.

59. Lawver, Renée A; Anex, Robert P; Lund, Jay R; Tchobanoglous, George; Alaniz, Victor; Booher, Clay; Edgar, Evan, (1993) GIGO A Spreadsheet Programme for Integrated Municipal Solid Waste Management, Department of Civil and Environmental Engineering, University of California, USA.

60. Le Goux, Jean-Yves and Le Douce, Catherine, (1995) *L'incinération des déchets Ménagers*, Ed. Economica, France, pp. 226.

61. Lee, Michael Hosung (1997) Cost And Business Analysis Module (CABAM), Final Report and User's Manual, Georgia Institute of Technology School of Aerospace Engineering, Atlanta, GA (rev. A) USA, 27p.

62. Lucks, Steve (2001) Electricity Reform Task Force, Perth, Australia, 3 p.

63. Maurel, Frederic, (2000) *Compte rendu de Mission, mission No. 2, Khon Kaen*, Thailand, pp. 16.

64. Mehta, Dinesh (*1998*) Urban Governance: Lessons From Best Practices In Asia UMP-Asia Occasional Paper No. 40, Thailand, 26 pages p.4

65. Mehta, Dinesh (*1998*) Urban Governance: Lessons From Best Practices In Asia UMP-Asia Occasional Paper No. 40, Thailand, 26 pages p.7

66. Ministry of Science, Technology and Environment (1999) *Standard urban waste procedures and regulations,* Thailand, pp. 100.

67. Muttamara, S and Shing Tet Leong (2004) *The Evolution of Solid Waste, Management in Bangkok: Implications for the Future,* Thammasat Int. J. Sc. Tech., Vol. 9, No. 1.

68. Nair, Chandran, (1993) *Solid waste management in emerging industrialized countries*, ERM Consulting Group, Thailand, pp. 9.

69. National Economic and Social development Board, (1997) *The Eight National Economic and Social Development Plan (1997 – 2001),* Thailand, pp. 145.

70. National Economic and Social development Board, (2002) *The Ninth National Economic and Social Development Plan (2002 – 2006),* Thailand, pp. 115.

71. Opasawatchai, Sakchai, (1983) *Anaerobic digestion and bio-gas production of garbage by thermophilic bacteria*, Department of Sanitary Engineering, Chulalongkorn University, Thailand, pp. 111.

72. Pawanan, Eakchai, (1997) *Upgrading of hospital waste management, A Case study in Bangkok*, Asian Institute of Technology, School of environment, resources and development, Thailand, pp. 149.

73. Peter, Wehrle, Karl and Christen, Jürg, UNDP/UNCHS Habitat)/World Bank/SDC (1996) Collaborative Programme on Municipal Solid Waste management in Low-Income Countries URBAN MANAGEMENT AND INFRASTRUCTURE, *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries,* Working Paper No. 9. USA, 59 p. p.9

74. Piyaprasit, Chatchaval, (1996) *Estimation of municipal solid waste generation rate and composition in Khon Kaen Municipality*, Department of Environmental Engineering, Chulalongkorn University, Thailand, pp. 198.

75. Pollution Control Department, Ministry of environment, (1998) *Regulations and guidelines on Municipal solid waste management*, Thailand, pp. 72.

76. Pollution Control Department, Ministry of Science, Technology and Environment, (2000) *Water Quality Standards & Criteria in Thailand*, Thailand, pp. 210.

77. Pollution Control Department, Ministry of Science, Technology and Environment (1997) *Laws and Standards On Pollution Control in Thailand, 4th Edition*, Thailand, pp. 285.

78. Ravanich, Dante, (1989) *Evaluation of the behavior of Bangkok municipal solid waste composting process,* Asian Institute of Technology, Thailand, pp. 95.

79. Regional Institute of Environmental Technology, (2000) *Thailand Environmental, Health &* Safety (EHS) Legislation, An updating Service. RIET, Singapore, pp. 548.

80. Ressources naturelles Canada et al, (2002) *Guide sur les possibilités d'accroître l'efficacité énergétique dans l'industrie de la transformation des viandes et volailles, des boissons et de la transformation du lait*, Canada, 102 p.

81. Ruesch, Paul, (2000) Illegal Dumping Economic Assessment (IDEA), Cost Estimating Model Version 1.2 U.S. Environmental Protection Agency Region 5, USA.

82. Sawyer, Clair; McCarty, Perry L., Parkin, Gene F., (1994) *Chemistry for environmental engineering,* McGraw-Hill International editions, Civil Engineering Series, pp. 658.

83. Schübeler, Peter, Wehrle, Karl and Christen, Jürg, UNDP/UNCHS Habitat)/World Bank/SDC (1996) Collaborative Programme on Municipal Solid Waste management in Low-Income Countries URBAN MANAGEMENT AND INFRASTRUCTURE, *Conceptual Framework for Municipal Solid Waste Management in Low-Income Countries,* Working Paper No. 9. 59 p. USA, p.9

84. Siam Tech Group, (2000) *The study project of preparing the plan for improving the efficiency of district solid waste management*, Executive summary, Department of Public Cleansing, Bangkok Metropolitan Administration, Thailand, pp. 58.

85. Silvert, William, (1997) Ecological Impact Classification with Fuzzy Sets, Ecological Modelling Co. 96, pp. 1-10, Dartmouth, Nova Scotia, Canada..

86. Silvert, William, (1999) Fuzzy Indices of Environmental Conditions, *Elsevier Pub. Ecological Modelling 130/1-3: USA, 111-119*.

87. SPSS (Statistical Package for the Social Sciences) software, (1999) SPSS, Chicago Il., USA.

88. Srinookoon, Chinatana, (1999) *Household waste minimization in Bangkok Metropolis*, Center for Developing Cities (Canberra), Thailand, pp. 39.

89. Srisooti, Suttiphant, (1998) *Site Selection of transfer stations for solid waste transportation system by using computer programme*, Department of environmental Engineering, Chulalongkorn University, Thailand, pp. 184.

90. Srisukontanun, Nat, April (1999) *Strategic planning and management of solid waste in Bangkok*, Asian Institute of technology, School of Civil Engineering, Thailand , pp. 53.

91. Suparee, Thosapol, (1998) *Solid waste facilities planning: A case study of Nakhon Pathom Province*, Asian Institute of Technology, School of Civil Engineering, Thailand, pp. 78.

92. Tchobanoglous, George, Theisen, Hilary, Vigil, Samuel. (1993) Integrated Solid Waste Management; Engineering Principles and Management Issues, McGraw-Hill Inc. International Edition, Singapore, 978 p.

93. Tchobanoglous, George; Theisen, Hilary; Vigil, Samuel, (1993) *Integrated Solid Waste Management, Engineering principles and management issues*, McGraw-Hill, Inc., USA, pp. 978.

94. Team Consulting Engineers Co., Ltd. Quality Team Consultant Ltd., (1999) *Master planning study for waste management of Bangkok Metropolis; Executive Summary,* Kingdom of Thailand, Bangkok Metropolitan Administration, December, Thailand, pp. 38.

95. Team Consulting Engineers Co., Ltd. Quality Team Consultant Ltd., (1999) *Master planning study for waste management of Bangkok Metropolis,* Kingdom of Thailand, Bangkok Metropolitan Administration, December, Thailand, pp. 350.

96. TRAN, LIEM T.; KNIGHT, C. GREGORY; O'NEILL, ROBERT V.; SMITH, ELIZABETH R.; RITTERS, KURT H.; WICKHAM, JAMES; (2002) ENVIRONMENTAL ASSESSMENT Fuzzy Decision Analysis for Integrated Environmental Vulnerability Assessment of the Mid-Atlantic Region, New York, USA, 15 pages

97. UNCHS (Habitat) (1999): Transfer of Appropriate Technology, Semi-Aerobic Landfill Method: Fukuoka Method, Kenya.

98. UNCHS (Habitat)(1996): Review of Human Settlements in Eastern Pacific Countries – Western Samoa, Cook Islands and Niue, Kenya.

99. UNEP (2002) A Directory of Environmentally Sound Technologies for the Integrated Management of Solid, Liquid and hazardous Waste for Small Island Developing States (SIDS) in the Pacific Region, Kenya, 124 pages.

100. UNEP (2001) State of the Environment - South Asia 2001, PART II • KEY ENVIRONMENTAL CONCERNS, 4.0 Urbanisation, Kenya, 154p., p.90

101. UNEP, (2001) State of the Environment - South Asia 2001, PART II • KEY ENVIRONMENTAL CONCERNS, 4.0 Urbanisation, Kenya, 154p., p.89V

102. UNEP, (2001) State of the Environment - South Asia 2001, PART II • KEY ENVIRONMENTAL CONCERNS, 4.0 Urbanisation, Kenya, 154p. p.91

103. UNEP, (2002) State of Waste Management in South East Asia, http://www.unep.or.jp/ietc/publications/spc/State_of_waste_Management/index.asp

104. UNEP, (2001) State of the environment, http://www.eapap.unep.org/reports/soe/.

105. UNESCAP, **(**2001) Activities Chapter Seventeen, Thailand, p.357

106. United Nations Center for Human Settlements, (1991) UMP Asia News, Urban Management Programme, Kenya, 12 pages p.4

107. United States Environmental Protection Agency (USEPA) (1995) Decision-maker's Guide to Solid Waste Management, Volume II, Solid and Hazardous Waste Education Center, University of Wisconsin–Extension and Department of Engineering Professional Development University of Wisconsin, Washington, D.C. USA.

108. United States Environmental Protection Agency (USEPA) (1997) Full Cost Accounting for Municipal Solid Waste Management: A Handbook, Solid Waste and Emergency Response, USA, 72 p.

109. Van de Klundert, Arnold, (2000) *Working paper for UWEP/CWG,– Draft THE SUSTAINABILITY OF ALLIANCES* BETWEEN STAKEHOLDERS IN WASTE MANAGEMENT, The Netherlands. 22 p.

110. Von Einsiedel, Nathanierl, (1998) *Estimation considerations of solid waste disposal in Asian cities*, UNDP/UNCHS Urban Waste Management Programme, USA, pp. 18.

111. Walhi, J., (2001). A long way to zero waste management, In: Proceedings of the Waste-Not-Asia Conference, Global Alliance for Incinerator Alternatives (GAIA), Taiwan, pp. 25-30

112. Wanichkul, Supat, (1993) L*eachate treatment using calcium carbonate precipitation,* Department of Environmental Engineering, Chulalongkorn University, Thailand, pp. 132.

113. Wikipedia, (2007), http://en.wikipedia.org/wiki/Bangkok

114. Wolf-Wats, Camilla, IVL; Jönbrink, Anna Karin IVF; Erixon, Maria CPM; Olsson, Pär SIK; Wallén, Erik SIK; (2000) LCA Software Survey, IVL Swedish Environmental Research Institute Ltd. Report No B 1390, Sweden, 203 p.

115. World Bank, (2004) Cambodia, Environmental Health Country Profile, USA. 22p.

116. World Bank, (2001) The Philippines Environment Monitor 2001. Philippines. 10 p.

117. World Bank, (2003) Thailand Environment Monitor 2003, Chapter 3. Thailand, 8 p.

118. Zurbrügg, Christian. (2002) Department of Water and Sanitation in Developing Countries (SANDEC), Swiss Federal Institute for Environmental Science and Technology (EAWAG), Urban Solid Waste Management in Low-Income Countries of Asia How to Cope with the Garbage Crisis Presented for: Scientific Committee on Problems of the Environment (SCOPE) Urban Solid Waste Management Review Session, Durban, South Africa, 13p.

ANNEXES

ANNEX I. Directive 2000/76/EC on incineration

Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste

DIRECTIVE 2000/76/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 4 December 2000
on the incineration of waste

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 175(1) thereof,

Having regard to the proposal from the Commission [1],

Having regard to the Opinion of the Economic and Social Committee [2],

Having regard to the Opinion of the Committee of the Regions [3],

Acting in accordance with the procedure laid down in Article 251 of the Treaty [4], and in the light of the joint text approved by the Conciliation Committee on 11 October 2000,

Whereas:

(1) The fifth Environment Action Programme: Towards sustainability — A European Community programme of policy and action in relation to the environment and sustainable development, supplemented by Decision No 2179/98/EC on its review [5], sets as an objective that critical loads and levels of certain pollutants such as nitrogen oxides (NO_x), sulphur dioxide (SO_2), heavy metals and dioxins should not be exceeded, while in terms of air quality the objective is that all people should be effectively protected against recognised health risks from air pollution. That Programme further sets as an objective a 90 % reduction of dioxin emissions of identified sources by 2005 (1985 level) and at least 70 % reduction from all pathways of cadmium (Cd), mercury (Hg) and lead (Pb) emissions in 1995.

(2) The Protocol on persistent organic pollutants signed by the Community within the framework of the United Nations Economic Commission for Europe (UN-ECE) Convention on long-range transboundary air pollution sets legally binding limit values for the emission of dioxins and furans of 0,1 ng/m; TE (Toxicity Equivalents) for installations burning more than 3 tonnes per hour of municipal solid waste, 0,5 ng/m; TE for installations burning more than 1 tonne per hour of medical waste, and 0,2 ng/m; TE for installations burning more than 1 tonne per hour of hazardous waste.

(3) The Protocol on Heavy Metals signed by the Community within the framework of the UN-ECE Convention on long-range transboundary air pollution sets legally binding limit values for the emission of particulate of 10 mg/m³ for hazardous and medical waste incineration and for the emission of mercury of 0,05 mg/m³ for hazardous waste incineration and 0,08 mg/m³ for municipal waste incineration.

(4) The International Agency for Research on Cancer and the World Health Organisation indicate that some polycyclic aromatic hydrocarbons (PAHs) are carcinogenic. Therefore, Member States may set emission limit values for PAHs among other pollutants.

(5) In accordance with the principles of subsidiarity and proportionality as set out in Article 5 of the Treaty, there is a need to take action at the level of the Community. The precautionary principle provides the basis for further measures. This Directive confines itself to minimum requirements for incineration and co-incineration plants.

(6) Further, Article 174 provides that Community policy on the environment is to contribute to protecting human health.

(7) Therefore, a high level of environmental protection and human health protection requires the setting and maintaining of stringent operational conditions, technical requirements and emission limit values for plants incinerating or co-incinerating waste within the Community. The limit values set should prevent or limit as far as practicable negative effects on the environment and the resulting risks to human health.

(8) The Communication from the Commission on the review of the Community Strategy for waste management assigns prevention of waste the first priority, followed by reuse and recovery and finally by safe disposal of waste; in its Resolution of 24 February 1997 on a Community Strategy for waste management [6], the Council reiterated its conviction that waste prevention should be the first priority of any rational waste policy in relation to minimising waste production and the hazardous properties of waste.

---

[1] OJ C 13, 17.1.1998, p. 6 and OJ C 372, 2.12.1998, p. 11.
[2] OJ C 116, 28.4.1999, p. 40.
[3] OJ C 198, 14.7.1999, p. 37.
[4] Opinion of the European Parliament of 14 April 1999 (OJ C 219, 30.7.1999, p. 249), Council Common Position of 25 November 1999 (OJ C 25, 28.1.2000, p. 17) and Decision of the European Parliament of 15 March 2000 (not yet published in the Official Journal). Decision of the European Parliament of 16 November 2000 and Decision of the Council of 20 November 2000.
[5] OJ C 138, 17.5.1993, p. 1 and OJ L 275, 10.10.1998, p. 1.
[6] OJ C 76, 11.3.1997, p. 1.

(9) In its Resolution of 24 February 1997 the Council also underlines the importance of Community criteria concerning the use of waste, the need for appropriate emission standards to apply to incineration facilities, the need for monitoring measures to be envisaged for existing incineration plants, and the need for the Commission to consider amending Community legislation in relation to the incineration of waste with energy recovery in order to avoid large-scale movements of waste for incineration or co-incineration in the Community.

(10) It is necessary to set strict rules for all plants incinerating or co-incinerating waste in order to avoid transboundary movements to plants operating at lower costs due to less stringent environmental standards.

(11) The Communication from the Commission/energy for the future: renewable sources of energy/White paper for a Community strategy and action plan takes into consideration in particular the use of biomass for energy purposes.

(12) Council Directive 96/61/EC [1] sets out an integrated approach to pollution prevention and control in which all the aspects of an installations environmental performance are considered in an integrated manner. Installations for the incineration of municipal waste with a capacity exceeding 3 tonnes per hour and installations for the disposal or recovery of hazardous waste with a capacity exceeding 10 tonnes per day are included within the scope of the said Directive.

(13) Compliance with the emission limit values laid down by this Directive should be regarded as a necessary but not sufficient condition for compliance with the requirements of Directive 96/61/EC. Such compliance may involve more stringent emissions limit values for the pollutants envisaged by this Directive, emission limit values for other substances and other media, and other appropriate conditions.

(14) Industrial experience in the implementation of techniques for the reduction of polluting emissions from incineration plants has been acquired over a period of ten years.

(15) Council Directives 89/369/EEC [2] and 89/429/EEC [3] on the prevention and reduction of air pollution from municipal waste incineration plants have contributed to the reduction and control of atmospheric emissions from incineration plants. More stringent rules should now be adopted and those Directives should accordingly be repealed.

(16) The distinction between hazardous and non-hazardous waste is based principally on the properties of waste prior to incineration or co-incineration but not on differences in emissions. The same emission limit values should apply to the incineration or co-incineration of hazardous and non-hazardous waste but different techniques and conditions of incineration or co-incineration and different monitoring measures upon reception of waste should be retained.

(17) Member States should take into account Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air [4] when implementing this Directive.

(18) The incineration of hazardous waste with a content of more than 1 % of halogenated organic substances, expressed as chlorine, has to comply with certain operational conditions in order to destroy as many organic pollutants such as dioxins as possible.

(19) The incineration of waste which contains chlorine generates flue gas residues. Such residues should be managed in a way that minimises their amount and harmfulness.

(20) There may be grounds to provide for specified exemptions to the emission limit values for some pollutants during a specified time limit and subject to specific conditions.

(21) Criteria for certain sorted combustible fraction of non-hazardous waste not suitable for recycling, should be developed in order to allow the authorisation of the reduction of the frequency of periodical measurements.

(22) A single text on the incineration of waste will improve legal clarity and enforceability. There should be a single directive for the incineration and co-incineration of hazardous and non-hazardous waste taking fully into account the substance and structure of Council Directive 94/67/EC of 16 December 1994 on the incineration of hazardous waste [5]. Therefore Directive 94/67/EC should also be repealed.

(23) Article 4 of Council Directive 75/442/EEC of 15 July 1975 on waste [6] requires Member States to take the necessary measures to ensure that waste is recovered or disposed of without endangering human health and without harming the environment. To this end, Articles 9 and 10 of that Directive provide that any plant or undertaking treating waste must obtain a permit from the competent authorities relating, *inter alia*, to the precautions to be taken.

---

[1] OJ L 257, 10.10.1996, p. 26.
[2] OJ L 163, 14.6.1989, p. 32. Directive as last amended by the Accession Act of 1994.
[3] OJ L 203, 15.7.1989, p. 50. Directive as last amended by the Accession Act of 1994.
[4] OJ L 163, 29.6.1999, p. 41.
[5] OJ L 365, 31.12.1994, p. 34.
[6] OJ L 194, 25.7.1975, p. 39. Directive as last amended by Commission Decision 350/96/EC (OJ L 135, 6.6.1996, p. 32).

(24) The requirements for recovering the heat generated by the incineration or co-incineration process and for minimising and recycling residues resulting from the operation of incineration or co-incineration plants will assist in meeting the objectives of Article 3 on the waste hierarchy of Directive 75/442/EEC.

(25) Incineration and co-incineration plants treating only animal waste regulated by Directive 90/667/EEC (1) are excluded from the scope of this Directive. The Commission intends to propose a revision to the requirements of Directive 90/667 with a view to providing for high environmental standards for the incineration and co-incineration of animal waste.

(26) The permit for an incineration or co-incineration plant shall also comply with any applicable requirements laid down in Directives 91/271/EEC (2), 96/61/EC, 96/62/EC (3), 76/464/EEC (4), and 1999/31/EC (5).

(27) The co-incineration of waste in plants not primarily intended to incinerate waste should not be allowed to cause higher emissions of polluting substances in that part of the exhaust gas volume resulting from such co-incineration than those permitted for dedicated incineration plants and should therefore be subject to appropriate limitations.

(28) High-standard measurement techniques are required to monitor emissions to ensure compliance with the emission limit values for the pollutants.

(29) The introduction of emission limit values for the discharge of waste water from the cleaning of exhaust gases from incineration and co-incineration plants will limit a transfer of pollutants from the air into water.

(30) Provisions should be laid down for cases where the emission limit values are exceeded as well as for technically unavoidable stoppages, disturbances or failures of the purification devices or the measurement devices.

(31) In order to ensure transparency of the permitting process throughout the Community the public should have access to information with a view to allowing it to be involved in decisions to be taken following applications for new permits and their subsequent updates. The public should have access to reports on the functioning and monitoring of the plants burning more than three tonnes per hour in order to be informed of their potential effects on the environment and human health.

(32) The Commission should present a report both to the European Parliament and the Council based on the experience of applying this Directive, the new scientific knowledge gained, the development of the state of technology, the progress achieved in emission control techniques, and on the experience made in waste management and operation of the plants and on the development of environmental requirements, with a view to proposing, as appropriate, to adapt the related provisions of this Directive.

(33) The measures necessary for the implementation of this Directive are to be adopted in accordance with Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission (6).

(34) Member States should lay down rules on penalties applicable to infringements of the provisions of this Directive and ensure that they are implemented; those penalties should be effective, proportionate and dissuasive,

HAVE ADOPTED THIS DIRECTIVE:

Article 1

Objectives

The aim of this Directive is to prevent or to limit as far as practicable negative effects on the environment, in particular pollution by emissions into air, soil, surface water and groundwater, and the resulting risks to human health, from the incineration and co-incineration of waste.

This aim shall be met by means of stringent operational conditions and technical requirements, through setting emission limit values for waste incineration and co-incineration plants within the Community and also through meeting the requirements of Directive 75/442/EEC.

Article 2

Scope

1. This Directive covers incineration and co-incineration plants.

(1) Council Directive 90/667/EEC of 27 November 1990 laying down the veterinary rules for the disposal and processing of animal waste, for its placing on the market and for the prevention of pathogens in feedstuffs of animal or fish origin and amending Directive 90/425/EEC (OJ L 363, 27.12.1990, p. 51). Directive as last amended by the Accession Act of 1994.

(2) Council Directive 91/271/EEC of 21 May 1991 concerning urban waste-water treatment (OJ L 135, 30.5.1991, p. 40). Directive as amended by Directive 98/15/EC (OJ L 67, 7.3.1998, p. 29).

(3) Council Directive 96/62/EC of 27 September 1996 on ambient air quality assessment and management (OJ L 296, 21.11.1996, p. 55).

(4) Council Directive 76/464/EEC of 4 May 1976 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (OJ L 129, 18.5.1976, p. 23). Directive as last amended by the Accession Act of 1994.

(5) Directive 1999/31/EC of 26 April 1999 on the landfill of waste (OJ L 182, 16.7.1999, p. 1).

(6) OJ L 184, 17.7.1999, p. 23.

2. The following plants shall however be excluded from the scope of this Directive:

(a) Plants treating only the following wastes:

(i) vegetable waste from agriculture and forestry,

(ii) vegetable waste from the food processing industry, if the heat generated is recovered,

(iii) fibrous vegetable waste from virgin pulp production and from production of paper from pulp, if it is co-incinerated at the place of production and the heat generated is recovered,

(iv) wood waste with the exception of wood waste which may contain halogenated organic compounds or heavy metals as a result of treatment with wood-preservatives or coating, and which includes in particular such wood waste originating from construction and demolition waste,

(v) cork waste,

(vi) radioactive waste,

(vii) animal carcasses as regulated by Directive 90/667/EEC without prejudice to its future amendements,

(viii) waste resulting from the exploration for, and the exploitation of, oil and gas resources from off-shore installations and incinerated on board the installation;

(b) Experimental plants used for research, development and testing in order to improve the incineration process and which treat less than 50 tonnes of waste per year.

Article 3

Definitions

For the purposes of this Directive:

1. 'waste' means any solid or liquid waste as defined in Article 1(a) of Directive 75/442/EEC;

2. 'hazardous waste' means any solid or liquid waste as defined in Article 1(4) of Council Directive 91/689/EEC of 12 December 1991 on hazardous waste [1].

For the following hazardous wastes, the specific requirements for hazardous waste in this Directive shall not apply:

(a) combustible liquid wastes including waste oils as defined in Article 1 of Council Directive 75/439/EEC of 16 June 1975 on the disposal of waste oils [2] provided that they meet the following criteria:

(i) the mass content of polychlorinated aromatic hydrocarbons, e.g. polychlorinated biphenyls (PCB) or pentachlorinated phenol (PCP) amounts to concentrations not higher than those set out in the relevant Community legislation;

(ii) these wastes are not rendered hazardous by virtue of containing other constituents listed in Annex II to Directive 91/689/EEC in quantities or in concentrations which are inconsistent with the achievement of the objectives set out in Article 4 of Directive 75/442/EEC; and

(iii) the net calorific value amounts to at least 30 MJ per kilogramme,

(b) any combustible liquid wastes which cannot cause, in the flue gas directly resulting from their combustion, emissions other than those from gasoil as defined in Article 1(1) of Directive 93/12/EEC [3] or a higher concentration of emissions than those resulting from the combustion of gasoil as so defined;

3. 'mixed municipal waste' means waste from households as well as commercial, industrial and institutional waste, which because of its nature and composition is similar to waste from households, but excluding fractions indicated in the Annex to Decision 94/3/EC [4] under heading 20 01 that are collected separately at source and excluding the other wastes indicated under heading 20 02 of that Annex;

4. 'incineration plant' means any stationary or mobile technical unit and equipment dedicated to the thermal treatment of wastes with or without recovery of the combustion heat generated. This includes the incineration by oxidation of waste as well as other thermal treatment processes such as pyrolysis, gasification or plasma processes in so far as the substances resulting from the treatment are subsequently incinerated.

This definition covers the site and the entire incineration plant including all incineration lines, waste reception, storage, on site pretreatment facilities, waste-fuel and air-supply systems, boiler, facilities for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, stack, devices and systems for controlling incineration operations, recording and monitoring incineration conditions;

5. 'co-incineration plant' means any stationary or mobile plant whose main purpose is the generation of energy or production of material products and:

— which uses wastes as a regular or additional fuel; or

— in which waste is thermally treated for the purpose of disposal.

[1] OJ L 377, 31.12.1991, p. 20. Directive as amended by Directive 94/31/EC (OJ L 168, 2.7.1994, p. 28).
[2] OJ L 194, 25.7.1975, p. 23. Directive as last amended by the Accession Act of 1994.
[3] Council Directive 93/12/EEC of 23 March 1993 relating to the sulphur content of certain liquid fuels (OJ L 74, 27.3.1993, p. 81). Directive as last amended by Directive 1999/32/EC (OJ L 121,11.5.1999, p. 13).
[4] Commission Decision 94/3/EC of 20 December 1993 establishing a list of wastes pursuant to Article 1a of Council Directive 75/442/EEC on waste (OJ L 5, 7.1.1994, p. 15).

If co-incineration takes place in such a way that the main purpose of the plant is not the generation of energy or production of material products but rather the thermal treatment of waste, the plant shall be regarded as an incineration plant within the meaning of point 4.

This definition covers the site and the entire plant including all co-incineration lines, waste reception, storage, on site pretreatment facilities, waste-, fuel- and air-supply systems, boiler, facilities for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, stack devices and systems for controlling incineration operations, recording and monitoring incineration conditions;

6. 'existing co-incineration or co-incineration plant' means an incineration or co-incineration plant:

(a) which is in operation and has a permit in accordance with existing Community legislation before 28 December 2002, or,

(b) which is authorised or registered for incineration or co-incineration and has a permit issued before 28 December 2002 in accordance with existing Community legislation, provided that the plant is put into operation not later than 28 December 2003, or

(c) which, in the view of the competent authority, is the subject of a full request for a permit, before 28 December 2002, provided that the plant is put into operation not later than 28 December 2004;

7. 'nominal capacity' means the sum of the incineration capacities of the furnaces of which an incineration plant is composed, as specified by the constructor and confirmed by the operator, with due account being taken, in particular, of the calorific value of the waste, expressed as the quantity of waste incinerated per hour;

8. 'emission' means the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the plant into the air, water or soil;

9. 'emission limit values' means the mass, expressed in terms of certain specific parameters, concentration and/or level of an emission, which may not be exceeded during one or more periods of time;

10. 'dioxins and furans' means all polychlorinated dibenzo-p-dioxins and dibenzofurans listed in Annex I;

11. 'operator' means any natural or legal person who operates or controls the plant or, where this is provided for in national legislation, to whom decisive economic power over the technical functioning of the plant has been delegated;

12. 'permit' means a written decision (or several such decisions) delivered by the competent authority granting authorisation to operate a plant, subject to certain conditions which guarantee that the plant complies with all the requirements of this Directive. A permit may cover one or more plants or parts of a plant on the same site operated by the same operator;

13. 'residue' means any liquid or solid material (including bottom ash and slag, fly ash and boiler dust, solid reaction products from gas treatment, sewage sludge from the treatment of waste waters, spent catalysts and spent activated carbon) defined as waste in Article 1(a) of Directive 75/442/EEC, which is generated by the incineration or co-incineration process, the exhaust gas or waste water treatment or other processes within the incineration or co-incineration plant.

Article 4

Application and permit

1. Without prejudice to Article 11 of Directive 75/442/EEC or to Article 3 of Directive 91/689/EEC, no incineration or co-incineration plant shall operate without a permit to carry out these activities.

2. Without prejudice to Directive 96/61/EC, the application for a permit for an incineration or co-incineration plant to the competent authority shall include a description of the measures which are envisaged to guarantee that:

(a) the plant is designed, equipped and will be operated in such a manner that the requirements of this Directive are taking into account the categories of waste to be incinerated;

(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating;

(c) the residues will be minimised in their amount and harmfulness and recycled where appropriate;

(d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Community legislation.

3. The permit shall be granted only if the application shows that the proposed measurement techniques for emissions into the air comply with Annex III and, as regards water, comply with Annex III paragraphs 1 and 2.

4. The permit granted by the competent authority for an incineration or co-incineration plant shall, in addition to complying with any applicable requirement laid down in Directives 91/271/EEC, 96/61/EC, 96/62/EC, 76/464/EEC and 1999/31/EC:

(a) list explicitly the categories of waste which may be treated. The list shall use at least the categories of waste set up in the European Waste Catalogue (EWC), if possible, and contain information on the quantity of waste, where appropriate;

If co-incineration takes place in such a way that the main purpose of the plant is not the generation of energy or production of material products but rather the thermal treatment of waste, the plant shall be regarded as an incineration plant within the meaning of point 4.

This definition covers the site and the entire plant including all co-incineration lines, waste reception, storage, on site pretreatment facilities, waste-, fuel- and air-supply systems, boiler, facilities for the treatment of exhaust gases, on-site facilities for treatment or storage of residues and waste water, stack devices and systems for controlling incineration operations, recording and monitoring incineration conditions;

6. 'existing co-incineration or co-incineration plant' means an incineration or co-incineration plant:

(a) which is in operation and has a permit in accordance with existing Community legislation before 28 December 2002, or,

(b) which is authorised or registered for incineration or co-incineration and has a permit issued before 28 December 2002 in accordance with existing Community legislation, provided that the plant is put into operation not later than 28 December 2003, or

(c) which, in the view of the competent authority, is the subject of a full request for a permit, before 28 December 2002, provided that the plant is put into operation not later than 28 December 2004;

7. 'nominal capacity' means the sum of the incineration capacities of the furnaces of which an incineration plant is composed, as specified by the constructor and confirmed by the operator, with due account being taken, in particular, of the calorific value of the waste, expressed as the quantity of waste incinerated per hour;

8. 'emission' means the direct or indirect release of substances, vibrations, heat or noise from individual or diffuse sources in the plant into the air, water or soil;

9. 'emission limit values' means the mass, expressed in terms of certain specific parameters, concentration and/or level of an emission, which may not be exceeded during one or more periods of time;

10. 'dioxins and furans' means all polychlorinated dibenzo-p-dioxins and dibenzofurans listed in Annex I;

11. 'operator' means any natural or legal person who operates or controls the plant or, where this is provided for in national legislation, to whom decisive economic power over the technical functioning of the plant has been delegated;

12. 'permit' means a written decision (or several such decisions) delivered by the competent authority granting authorisation to operate a plant, subject to certain conditions which guarantee that the plant complies with all the requirements of this Directive. A permit may cover one or more plants or parts of a plant on the same site operated by the same operator;

13. 'residue' means any liquid or solid material (including bottom ash and slag, fly ash and boiler dust, solid reaction products from gas treatment, sewage sludge from the treatment of waste waters, spent catalysts and spent activated carbon) defined as waste in Article 1(a) of Directive 75/442/EEC, which is generated by the incineration or co-incineration process, the exhaust gas or waste water treatment or other processes within the incineration or co-incineration plant.

Article 4

Application and permit

1. Without prejudice to Article 11 of Directive 75/442/EEC or to Article 3 of Directive 91/689/EEC, no incineration or co-incineration plant shall operate without a permit to carry out these activities.

2. Without prejudice to Directive 96/61/EC, the application for a permit for an incineration or co-incineration plant to the competent authority shall include a description of the measures which are envisaged to guarantee that:

(a) the plant is designed, equipped and will be operated in such a manner that the requirements of this Directive are taking into account the categories of waste to be incinerated;

(b) the heat generated during the incineration and co-incineration process is recovered as far as practicable e.g. through combined heat and power, the generating of process steam or district heating;

(c) the residues will be minimised in their amount and harmfulness and recycled where appropriate;

(d) the disposal of the residues which cannot be prevented, reduced or recycled will be carried out in conformity with national and Community legislation.

3. The permit shall be granted only if the application shows that the proposed measurement techniques for emissions into the air comply with Annex III and, as regards water, comply with Annex III paragraphs 1 and 2.

4. The permit granted by the competent authority for an incineration or co-incineration plant shall, in addition to complying with any applicable requirement laid down in Directives 91/271/EEC, 96/61/EC, 96/62/EC, 76/464/EEC and 1999/31/EC:

(a) list explicitly the categories of waste which may be treated. The list shall use at least the categories of waste set up in the European Waste Catalogue (EWC), if possible, and contain information on the quantity of waste, where appropriate;

Incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the process is raised, after the last injection of combustion air, in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850 °C, as measured near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, for two seconds. If hazardous wastes with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are incinerated, the temperature has to be raised to 1 100 °C for at least two seconds.

Each line of the incineration plant shall be equipped with at least one auxiliary burner. This burner must be switched on automatically when the temperature of the combustion gases after the last injection of combustion air falls below 850 °C or 1 100 °C as the case may be. It shall also be used during plant start-up and shut-down operations in order to ensure that the temperature of 850 °C or 1 100 °C as the case may be is maintained at all times during these operations and as long as unburned waste is in the combustion chamber.

During start-up and shut-down or when the temperature of the combustion gas falls below 850 °C or 1 100 °C as the case may be, the auxiliary burner shall not be fed with fuels which can cause higher emissions than those resulting from the burning of gasoil as defined in Article 1(1) of Council Directive 75/716/EEC, liquefied gas or natural gas.

2. Co-incineration plants shall be designed, equipped, built and operated in such a way that the gas resulting from the co-incineration of waste is raised in a controlled and homogeneous fashion and even under the most unfavourable conditions, to a temperature of 850 °C for two seconds. If hazardous wastes with a content of more than 1 % of halogenated organic substances, expressed as chlorine, are co-incinerated, the temperature has to be raised to 1 100 °C.

3. Incineration and co-incineration plants shall have and operate an automatic system to prevent waste feed:

(a) at start-up, until the temperature of 850 °C or 1 100 °C as the case may be or the temperature specified according to paragraph 4 has been reached;

(b) whenever the temperature of 850 °C or 1 100 °C as the case may be or the temperature specified according to paragraph 4 is not maintained;

(c) whenever the continuous measurements required by this Directive show that any emission limit value is exceeded due to disturbances or failures of the purification devices.

4. Conditions different from those laid down in paragraph 1 and, as regards the temperature, paragraph 3 and specified in the permit for certain categories of waste or for certain thermal processes may be authorised by the competent authority, provided the requirements of this Directive are met. Member States may lay down rules governing these authorisations. The change of the operational conditions shall not cause more residues or residues with a higher content of organic pollutants compared to those residues which could be expected under the conditions laid down in paragraph 1.

Conditions different from those laid down in paragraph 2 and, as regards the temperature, paragraph 3 and specified in the permit for certain categories of waste or for certain thermal processes may be authorised by the competent authority, provided the requirements of this Directive are met. Member States may lay down rules governing these authorisations. Such authorisation shall be conditional upon at least the provisions for emission limit values set out in Annex V for total organic carbon and CO being complied with.

In the case of co-incineration of their own waste at the place of its production in existing bark boilers within the pulp and paper industry, such authorisation shall be conditional upon at least the provisions for emission limit values set out in Annex V for total organic carbon being complied with.

All operating conditions determined under this paragraph and the results of verifications made shall be communicated by the Member State to the Commission as part of the information provided in accordance with the reporting requirements.

5. Incineration and co-incineration plants shall be designed, equipped, built and operated in such a way as to prevent emissions into the air giving rise to significant ground-level air pollution; in particular, exhaust gases shall be discharged in a controlled fashion and in conformity with relevant Community air quality standards by means of a stack the height of which is calculated in such a way as to safeguard human health and the environment.

6. Any heat generated by the incineration or the co-incineration process shall be recovered as far as practicable.

7. Infectious clinical waste should be placed straight in the furnace, without first being mixed with other categories of waste and without direct handling.

8. The management of the incineration or the co-incineration plant shall be in the hands of a natural person who is competent to manage the plant.

Article 7

Air emission limit values

1. Incineration plants shall be designed, equipped, built and operated in such a way that the emission limit values set out in Annex V are not exceeded in the exhaust gas.

2. Co-incineration plants shall be designed, equipped, built and operated in such a way that the emission limit values determined according to or set out in Annex II are not exceeded in the exhaust gas.

If in a co-incineration plant more than 40 % of the resulting heat release comes from hazardous waste, the emission limit values set out in Annex V shall apply.

3. The results of the measurements made to verify compliance with the emission limit values shall be standardised with respect to the conditions laid down in Article 11.

4. In the case of co-incineration of untreated mixed municipal waste, the limit values will be determined according to Annex V, and Annex II will not apply.

5. Without prejudice to the provisions of the Treaty, Member States may set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

Artide 8

Water discharges from the cleaning of exhaust gases

1. Waste water from the cleaning of exhaust gases discharged from an incineration or co-incineration plant shall be subject to a permit granted by the competent authorities.

2. Discharges to the aquatic environment of waste water resulting from the cleaning of exhaust gases shall be limited as far as practicable, at least in accordance with the emission limit values set in Annex IV.

3. Subject to a specific provision in the permit, the waste water from the cleaning of exhaust gases may be discharged to the aquatic environment after separate treatment on condition that:

(a) the requirements of relevant Community, national and local provisions are complied with in the form of emission limit values; and

(b) the mass concentrations of the polluting substances referred to in Annex IV do not exceed the emission limit values laid down therein.

4. The emission limit values shall apply at the point where waste waters from the cleaning of exhaust gases containing the polluting substances referred to in Annex IV are discharged from the incineration or co-incineration plant.

Where the waste water from the cleaning of exhaust gases is treated on site collectively with other on-site sources of waste water, the operator shall take the measurements referred to in Article 11:

(a) on the waste water stream from the exhaust gas cleaning processes prior to its input into the collective waste water treatment plant;

(b) on the other waste water stream or streams prior to its or their input into the collective waste water treatment plant;

(c) at the point of final waste water discharge, after the treatment, from the incineration plant or co-incineration plant.

The operator shall take appropriate mass balance calculations in order to determine the emission levels in the final waste water discharge that can be attributed to the waste water arising from the cleaning of exhaust gases in order to check compliance with the emission limit values set out in Annex IV for the waste water stream from the exhaust gas cleaning process.

Under no circumstances shall dilution of waste water take place for the purpose of complying with the emission limit values set in Annex IV.

5. When waste waters from the cleaning of exhaust gases containing the polluting substances referred to in Annex IV are treated outside the incineration or co-incineration plant at a treatment plant intended only for the treatment of this sort of waste water, the emission limit values of Annex IV are to be applied at the point where the waste waters leave the treatment plant. If this off-site treatment plant is not only dedicated to treat waste water from incineration, the operator shall take the appropriate mass balance calculations, as provided for under paragraph 4(a), (b) and (c), in order to determine the emission levels in the final waste water discharge that can be attributed to the waste water arising from the cleaning of exhaust gases in order to check compliance with the emission limit values set out in Annex IV for the waste water stream from the exhaust gas cleaning process.

Under no circumstances shall dilution of waste water take place for the purpose of complying with the emission limit values set in Annex IV.

6. The permit shall:

(a) establish emission limit values for the polluting substances referred to in Annex IV, in accordance with paragraph 2 and in order to meet the requirements referred to in paragraph 3(a);

(b) set operational control parameters for waste water at least for pH, temperature and flow.

7. Incineration and co-incineration plant sites, including associated storage areas for wastes, shall be designed and in such a way as to prevent the unauthorised and accidental release of any polluting substances into soil, surface water and groundwater in accordance with the provisions provided for in relevant Community legislation. Moreover, storage capacity shall be provided for contaminated rainwater run-off from the incineration or co-incineration plant site or for contaminated water arising from spillage or fire-fighting operations.

The storage capacity shall be adequate to ensure that such waters can be tested and treated before discharge where necessary.

8. Without prejudice to the provisions of the Treaty, Member States may set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

Article 9

Residues

Residues resulting from the operation of the incineration or co-incineration plant shall be minimised in their amount and harmfulness. Residues shall be recycled, where appropriate, directly in the plant or outside in accordance with relevant Community legislation.

Transport and intermediate storage of dry residues in the form of dust, such as boiler dust and dry residues from the treatment of combustion gases, shall take place in such a way as to prevent dispersal in the environment e.g. in closed containers.

Prior to determining the routes for the disposal or recycling of the residues from incineration and co-incineration plants, appropriate tests shall be carried out to establish the physical and chemical characteristics and the polluting potential of the different incineration residues. The analysis shall concern the total soluble fraction and heavy metals soluble fraction.

Article 10

Control and monitoring

1. Measurement equipment shall be installed and techniques used in order to monitor the parameters, conditions and mass concentrations relevant to the incineration or co-incineration process.

2. The measurement requirements shall be laid down in the permit or in the conditions attached to the permit issued by the competent authority.

3. The appropriate installation and the functioning of the automated monitoring equipment for emissions into air and water shall be subject to control and to an annual surveillance test. Calibration has to be done by means of parallel measurements with the reference methods at least every three years.

4. The location of the sampling or measurement points shall be laid down by the competent authority.

5. Periodic measurements of the emissions into the air and water shall be carried out in accordance with Annex III, points 1 and 2.

Article 11

Measurement requirements

1. Member States shall, either by specification in the conditions of the permit or by general binding rules, ensure that paragraphs 2 to 12 and 17, as regards air, and paragraphs 9 and 14 to 17, as regards water, are complied with.

2. The following measurements of air pollutants shall be carried out in accordance with Annex III at the incineration and co-incineration plant:

(a) continuous measurements of the following substances: NO_x, provided that emission limit values are set, CO, total dust, TOC, HCl, HF, SO_2;

(b) continuous measurements of the following process operation parameters: temperature near the inner wall or at another representative point of the combustion chamber as authorised by the competent authority, concentration of oxygen, pressure, temperature and water vapour content of the exhaust gas;

(c) at least two measurements per year of heavy metals, dioxins and furans; one measurement at least every three months shall however be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

3. The residence time as well as the minimum temperature and the oxygen content of the exhaust gases shall be subject to appropriate verification, at least once when the incineration or co-incineration plant is brought into service and under the most unfavourable operating conditions anticipated.

4. The continuous measurement of HF may be omitted if treatment stages for HCl are used which ensure that the emission limit value for HCl is not being exceeded. In this case the emissions of HF shall be subject to periodic measurements as laid down in paragraph 2(c).

5. The continuous measurement of the water vapour content shall not be required if the sampled exhaust gas is dried before the emissions are analysed.

6. Periodic measurements as laid down in paragraph 2(c) of HCl, HF and SO_2 instead of continuous measuring may be authorised in the permit by the competent authority in incineration or co-incineration plants, if the operator can prove that the emissions of those pollutants can under no circumstances be higher than the prescribed emission limit values.

7. The reduction of the frequency of the periodic measurements for heavy metals from twice a year to once every two years and for dioxins and furans from twice a year to once every year may be authorised in the permit by the competent authority provided that the emissions resulting from co-incineration or incineration are below 50 % of the emission limit values determined according to Annex II or Annex V respectively and provided that criteria for the requirements to be met, developed in accordance with the procedure laid down in Article 17, are available. These criteria shall at least be based on the provisions of the second subparagraph, points (a) and (d).

Until 1 January 2005 the reduction of the frequency may be authorised even if no such criteria are available provided that:

(a) the waste to be co-incinerated or incinerated consists only of certain sorted combustible fractions of non-hazardous waste not suitable for recycling and presenting certain characteristics, and which is further specified on the basis of the assessment referred to in subparagraph (d);

(b) national quality criteria, which have been reported to the Commission, are available for these wastes;

(c) co-incineration and incineration of these wastes is in line with the relevant waste management plans referred to in Article 7 of Directive 75/442/EEC;

(d) the operator can prove to the competent authority that the emissions are under all circumstances significantly below the emission limit values set out in Annex II or Annex V for heavy metals, dioxins and furans; this assessment shall be based on information on the quality of the waste concerned and measurements of the emissions of the said pollutants;

(e) the quality criteria and the new period for the periodic measurements are specified in the permit; and

(f) all decisions on the frequency of measurements referred to in this paragraph, supplemented with information on the amount and quality of the waste concerned, shall be communicated on a yearly basis to the Commission.

8. The results of the measurements made to verify compliance with the emission limit values shall be standardised at the following conditions and for oxygen according to the formula as referred to in Annex VI:

(a) Temperature 273 K, pressure 101,3 kPa, 11 % oxygen, dry gas, in exhaust gas of incineration plants;

(b) Temperature 273 K, pressure 101,3 kPa, 3 % oxygen, dry gas, in exhaust gas of incineration of waste oil as defined in Directive 75/439/EEC;

(c) when the wastes are incinerated or co-incinerated in an oxygen-enriched atmosphere, the results of the measurements can be standardised at an oxygen content laid down by the competent authority reflecting the special circumstances of the individual case;

(d) in the case of co-incineration, the results of the measurements shall be standardised at a total oxygen content as calculated in Annex II.

When the emissions of pollutants are reduced by exhaust gas treatment in an incineration or co-incineration plant treating hazardous waste, the standardisation with respect to the oxygen contents provided for in the first subparagraph shall be done only if the oxygen content measured over the same period as for the pollutant concerned exceeds the relevant standard oxygen content.

9. All measurement results shall be recorded, processed and presented in an appropriate fashion in order to enable the competent authorities to verify compliance with the permitted operating conditions and emission limit values laid down in this Directive in accordance with procedures to be decided upon by those authorities.

10. The emission limit values for air shall be regarded as being complied with if:

(a) — none of the daily average values exceeds any of the emission limit values set out in Annex V(a) or Annex II;

— 97 % of the daily average value over the year does not exceed the emission limit value set out in Annex V(e) first indent;

(b) either none of the half-hourly average values exceeds any of the emission limit values set out in Annex V(b), column A or, where relevant, 97 % of the half-hourly average values over the year do not exceed any of the emission limit values set out in Annex V(b), column B;

(c) none of the average values over the sample period set out for heavy metals and dioxins and furans exceeds the emission limit values set out in Annex V(c) and (d) or Annex II;

(d) the provisions of Annex V(e), second indent or Annex II, are met.

11. The half-hourly average values and the 10-minute averages shall be determined within the effective operating time (excluding the start-up and shut-off periods if no waste is being incinerated) from the measured values after having subtracted the value of the confidence interval specified in point 3 of Annex III. The daily average values shall be determined from those validated average values.

To obtain a valid daily average value no more than five half-hourly average values in any day shall be discarded due to malfunction or maintenance of the continuous measurement system. No more than ten daily average values per year shall be discarded due to malfunction or maintenance of the continuous measurement system.

12. The average values over the sample period and the average values in the case of periodical measurements of HF, HCl and SO_2 shall be determined in accordance with the requirements of Article 10(2) and (4) and Annex III.

13. The Commission, acting in accordance with the procedure laid down in Article 17, shall decide, as soon as appropriate measurement techniques are available within the Community, the date from which continuous measurements of the air emission limit values for heavy metals, dioxins and furans shall be carried out in accordance with Annex III.

14. The following measurements shall be carried out at the point of waste water discharge:

(a) continuous measurements of the parameters referred to in Article 8(6)(b);

(b) spot sample daily measurements of total suspended solids; Member States may alternatively provide for measurements of a flow proportional representative sample over a period of 24 hours;

(c) at least monthly measurements of a flow proportional representative sample of the discharge over a period of 24 hours of the polluting substances referred to in Article 8(3) with respect to items 2 to 10 in Annex IV;

(d) at least every six months measurements of dioxins and furans; however one measurement at least every three months shall be carried out for the first 12 months of operation. Member States may fix measurement periods where they have set emission limit values for polycyclic aromatic hydrocarbons or other pollutants.

15. The monitoring of the mass of pollutants in the treated waste water shall be done in conformity with Community legislation and laid down in the permit as well as the frequency of the measurements.

16. The emission limit values for water shall be regarded as being complied with if:

(a) for total suspended solids (polluting substance number 1), 95 % and 100 % of the measured values do not exceed the respective emission limit values as set out in Annex IV;

(b) for heavy metals (polluting substances number 2 to 10) no more than one measurement per year exceeds the emission limit values set out in Annex IV; or, if the Member State provides for more than 20 samples per year, no more than 5 % of these samples exceed the emission limit values set out in Annex IV;

(c) for dioxins and furans (polluting substance 11), the twice-yearly measurements do not exceed the emission limit value set out in Annex IV.

17. Should the measurements taken show that the emission limit values for air or water laid down in this Directive have been exceeded, the competent authorities shall be informed without delay.

Article 12

Access to information and public participation

1. Without prejudice to Council Directive 90/313/EEC [1] and Directive 96/61/EC, applications for new permits for incineration and co-incineration plants shall be made available at one or more locations accessible to the public, such as local authority offices, for an appropriate period to enable it to comment on them before the competent authority reaches a decision. That decision, including at least a copy of the permit, and any subsequent updates, shall also be made available to the public.

2. For incineration or co-incineration plants with a nominal capacity of two tonnes or more per hour and notwithstanding Article 15(2) of Directive 96/61/EC, an annual report to be provided by the operator to the competent authority on the functioning and monitoring of the plant shall be made available to the public. This report shall, as a minimum requirement, give an account of the running of the process and the emissions into air and water compared with the emission standards in this Directive. A list of incineration or co-incineration plants with a nominal capacity of less than two tonnes per hour shall be drawn up by the competent authority and shall be made available to the public.

Article 13

Abnormal operating conditions

1. The competent authority shall lay down in the permit the maximum permissible period of any technically unavoidable stoppages, disturbances, or failures of the purification devices or the measurement devices, during which the concentrations in the discharges into the air and the purified waste water of the regulated substances may exceed the prescribed emission limit values.

2. In the case of a breakdown, the operator shall reduce or close down operations as soon as practicable until normal operations can be restored.

3. Without prejudice to Article 6(3)(c), the incineration plant or co-incineration plant or incineration line shall under no circumstances continue to incinerate waste for a period of more than four hours uninterrupted where emission limit values are exceeded; moreover, the cumulative duration of operation in such conditions over one year shall be less than 60 hours. The 60-hour duration applies to those lines of the entire plant which are linked to one single flue gas cleaning device.

4. The total dust content of the emissions into the air of an incineration plant shall under no circumstances exceed 150 mg/m³ expressed as a half-hourly average; moreover the air emission limit values for CO and TOC shall not be exceeded. All other conditions referred to in Article 6 shall be complied with.

Article 14

Review clause

Without prejudice to Directive 96/61/EC, the Commission shall submit a report to the European Parliament and the Council before 31 December 2008 based on experience of the application of this Directive, in particular for new plants, and on the progress achieved in emission control techniques and experience in waste management. Furthermore, the report shall be based on the development of the state of technology, of experience in the operation of the plants, of environmental requirements. This report will include a specific section on the application of Annex II.1.1. and in particular on the economic and technical feasibility for existing cement kilns as referred to in the footnote to Annex II.1.1. of respecting the NO_x emission limit value for new cement kilns set out in that Annex. The report shall, as appropriate, be accompanied by proposals for revision of the related provisions of this Directive. However, the Commission shall, if appropriate, propose an amendment for Annex II.3 before the said report, if major waste streams are directed to types of co-incineration plants other than those dealt with in Annex II.1 and II.2.

[1] Council Directive 90/313/EEC of 7 June 1990 on the freedom of access to information on the environment (OJ L 158, 23.6.1990, p. 56). Directive as last amended by the Accession Act of 1994.

Article 15

Reporting

The reports on the implementation of this Directive shall be established in accordance with the procedure laid down in Article 5 of Council Directive 91/692/EEC. The first report shall cover at least the first full three-year period after 28 December 2002 and comply with the periods referred to in Article 17 of Directive 94/67/EC and in Article 16(3) of Directive 96/61/EC. To this effect, the Commission shall elaborate the appropriate questionnaire in due time.

Article 16

Future adaptation of the directive

The Commission shall, in accordance with the procedure laid down in Article 17(2), amend Articles 10, 11 and 13 and Annexes I and III in order to adapt them to technical progress or new findings concerning the health benefits of emission reductions.

Article 17

Regulatory committee

1. The Commission shall be assisted by a regulatory committee.

2. Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. The committee shall adopt its own rules of procedure.

Article 18

Repeal

The following shall be repealed as from 28 December 2005:

(a) Article 8(1) and the Annex to Directive 75/439/EEC;

(b) Directive 89/369/EEC;

(c) Directive 89/429/EEC;

(d) Directive 94/67/EC.

Article 19

Penalties

The Member States shall determine penalties applicable to breaches of the national provisions adopted pursuant to this Directive. The penalties thus provided for shall be effective, proportionate and dissuasive. The Member States shall notify those provisions to the Commission by 28 December 2002 at the latest and shall notify it without delay of any subsequent amendment affecting them.

Article 20

Transitional provisions

1. Without prejudice to the specific transitional provisions provided for in the Annexes to this Directive, the provisions of this Directive shall apply to existing plants as from 28 December 2005.

2. For new plants, i.e. plants not falling under the definition of 'existing incineration or co-incineration plant' in Article 3(6) or paragraph 3 of this Article, this Directive, instead of the Directives mentioned in Article 18, shall apply as from 28 December 2002.

3. Stationary or mobile plants whose purpose is the generation of energy or production of material products and which are in operation and have a permit in accordance with existing Community legislation where required and which start co-incinerating waste not later than 28 December 2004 are to be regarded as existing co-incineration plants.

Article 21

Implementation

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive not later than 28 December 2002. They shall forthwith inform the Commission thereof.

When Member States adopt those measures, they shall contain a reference to this Directive or be accompanied by such reference on the occasion of their official publication. The methods of making such reference shall be laid down by the Member States.

2. Member States shall communicate to the Commission the text of the provisions of domestic law which they adopt in the field governed by this Directive.

Article 22

Entry into force

This Directive shall enter into force on the day of its publication in the *Official Journal of the European Communities*.

Article 23

Addressees

This Directive is addressed to the Member States.

Done at Brussels, 4 December 2000.

For the European Parliament	*For the Council*
The President	*The President*
N. FONTAINE	F. VÉDRINE

ANNEX I

Equivalence factors for dibenzo-p-dioxins and dibenzofurans

For the determination of the total concentration (TE) of dioxins and furans, the mass concentrations of the following dibenzo-p-dioxins and dibenzofurans shall be multiplied by the following equivalence factors before summing:

		Toxic equivalence factor
2,3,7,8	— Tetrachlorodibenzodioxin (TCDD)	1
1,2,3,7,8	— Pentachlorodibenzodioxin (PeCDD)	0,5
1,2,3,4,7,8	— Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,6,7,8	— Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,7,8,9	— Hexachlorodibenzodioxin (HxCDD)	0,1
1,2,3,4,6,7,8	— Heptachlorodibenzodioxin (HpCDD)	0,01
	— Octachlorodibenzodioxin (OCDD)	0,001
2,3,7,8	— Tetrachlorodibenzofuran (TCDF)	0,1
2,3,4,7,8	— Pentachlorodibenzofuran (PeCDF)	0,5
1,2,3,7,8	— Pentachlorodibenzofuran (PeCDF)	0,05
1,2,3,4,7,8	— Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,6,7,8	— Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,7,8,9	— Hexachlorodibenzofuran (HxCDF)	0,1
2,3,4,6,7,8	— Hexachlorodibenzofuran (HxCDF)	0,1
1,2,3,4,6,7,8	— Heptachlorodibenzofuran (HpCDF)	0,01
1,2,3,4,7,8,9	— Heptachlorodibenzofuran (HpCDF)	0,01
	— Octachlorodibenzofuran (OCDF)	0,001

ANNEX II

DETERMINATION OF AIR EMISSION LIMIT VALUES FOR THE CO-INCINERATION OF WASTE

The following formula (mixing rule) is to be applied whenever a specific total emission limit value 'C' has not been set out in a table in this Annex.

The limit value for each relevant pollutant and carbon monoxide in the exhaust gas resulting from the co-incineration of waste shall be calculated as follows:

$$\frac{V_{waste} \times C_{waste} + V_{proc} \times C_{proc}}{V_{waste} + V_{proc}} = C$$

V_{waste}: exhaust gas volume resulting from the incineration of waste only determined from the waste with the lowest calorific value specified in the permit and standardised at the conditions given by this Directive.

If the resulting heat release from the incineration of hazardous waste amounts to less than 10 % of the total heat released in the plant, V_{waste} must be calculated from a (notional) quantity of waste that, being incinerated, would equal 10 % heat release, the total heat release being fixed.

C_{waste}: emission limit values set for incineration plants in Annex V for the relevant pollutants and carbon monoxide.

V_{proc}: exhaust gas volume resulting from the plant process including the combustion of the authorised fuels normally used in the plant (wastes excluded) determined on the basis of oxygen contents at which the emissions must be standardised as laid down in Community or national regulations. In the absence of regulations for this kind of plant, the real oxygen content in the exhaust gas without being thinned by addition of air unnecessary for the process must be used. The standardisation at the other conditions is given in this Directive.

C_{proc}: emission limit values as laid down in the tables of this annex for certain industrial sectors or in case of the absence of such a table or such values, emission limit values of the relevant pollutants and carbon monoxide in the flue gas of plants which comply with the national laws, regulations and administrative provisions for such plants while burning the normally authorised fuels (wastes excluded). In the absence of these measures the emission limit values laid down in the permit are used. In the absence of such permit values the real mass concentrations are used.

C: total emission limit values and oxygen content as laid down in the tables of this annex for certain industrial sectors and certain pollutants or in case of the absence of such a table or such values total emission limit values for CO and the relevant pollutants replacing the emission limit values as laid down in specific Annexes of this Directive. The total oxygen content to replace the oxygen content for the standardisation is calculated on the basis of the content above respecting the partial volumes.

Member States may lay down rules governing the exemptions provided for in this Annex.

II1. Special provisions for cement kilns co-incinerating waste

Daily average values (for continuous measurements) Sample periods and other measurement requirements as in Article 7. All values in mg/m^3 (Dioxins and furans ng/m^3). Half-hourly average values shall only be needed in view of calculating the daily average values.

The results of the measurements made to verify compliance with the emission limit values shall be standardised at the following conditions: Temperature 273 K, pressure 101,3 kPa, 10 % oxygen, dry gas.

II1.1. *C — total emission limit values*

Pollutant	C
Total dust	30
HCl	10
HF	1
NO_x for existing plants	800
NO_x for new plants	500 (1)

Pollutant	C
Cd + Tl	0,05
Hg	0,05
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0,5
Dioxins and furans	0,1

(*) For the implementation of the NO_2 emission limit values, cement kilns which are in operation and have a permit in accordance with existing Community legislation and which start co-incinerating waste after the date mentioned in Article 20(3) are not to be regarded as new plants.

Until 1 January 2008, exemptions for NO_2 may be authorised by the competent authorities for existing wet process cement kilns or cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value for NO_2 of not more than 1200 mg/m³.

Until 1 January 2008, exemptions for dust may be authorised by the competent authority for cement kilns which burn less than three tonnes of waste per hour, provided that the permit foresees a total emission limit value of not more than 50 mg/m³.

II1.2. *C — total emission limit values for SO_2 and TOC*

Pollutant	C
SO_2	50
TOC	10

Exemptions may be authorised by the competent authority in cases where TOC and SO_2 do not result from the incineration of waste.

II1.3. *Emission limit value for CO*

Emission limit values for CO can be set by the competent authority.

II.2. Special provisions for combustion plants co-incinerating waste

II.2.1. *Daily average values*

Without prejudice to Directive 88/609/EEC and in the case where, for large combustion plants, more stringent emission limit values are set according to future Community legislation, the latter shall replace, for the plants and pollutants concerned, the emission limit values as laid down in the following tables (C_{proc}). In that case, the following tables shall be adapted to these more stringent emission limit values in accordance with the procedure laid down in Article 17 without delay.

Half-hourly average values shall only be needed in view of calculating the daily average values.

C_{proc}:

C_{proc} for solid fuels expressed in mg/Nm³ (O_2 content 6 %):

Pollutants	< 50 MWth	50-100 MWth	100 to 300 MWth	> 300 MWth
SO_2				
general case		850	850 to 200 (linear decrease from 100 to 300 MWth)	200
indigenous fuels		or rate of desulphurisation ≥ 90 %	or rate of desulphurisation ≥ 92 %	or rate of desulphurisation ≥ 95 %
NO_2		400	300	200
Dust	50	50	30	30

Until 1 January 2007 and without prejudice to relevant Community legislation, the emission limit value for NO_2 does not apply to plants only co-incinerating hazardous waste.

Until 1 January 2008, exemptions for NO_x and SO_2 may be authorised by the competent authorities for existing co-incineration plants between 100 and 300 MWth using fluidised bed technology and burning solid fuels provided that the permit foresees a C_{proc} value of not more than 350 mg/Nm³ for NO_x and not more than 850 to 400 mg/Nm³ (linear decrease from 100 to 300 MWth) for SO_2.

C_{proc} for biomass expressed in mg/Nm³ (O_2 content 6 %):

'Biomass' means: products consisting of any whole or part of a vegetable matter from agriculture or forestry, which can be used for the purpose of recovering its energy content as well as wastes listed in Article 2(2)(a)(i) to (v).

Pollutants	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2		200	200	200
NO_x		350	300	300
Dust	50	50	30	30

Until 1 January 2008, exemptions for NO_x may be authorised by the competent authorities for existing co-incineration plants between 100 and 300 MWth using fluidised bed technology and burning biomass provided that the permit foresees a C_{proc} value of not more than 350 mg/Nm³.

C_{proc} for liquid fuels expressed in mg/Nm³ (O_2 content 3 %):

Pollutants	< 50 MWth	50 to 100 MWth	100 to 300 MWth	> 300 MWth
SO_2		850	850 to 200 (linear decrease from 100 to 300 MWth)	200
NO_x		400	300	200
Dust	50	50	30	30

II.2.2. *C — total emission limit values*

C expressed in mg/Nm³ (O_2 content 6 %). All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours:

Pollutant	C
Cd + Tl	0,05
Hg	0,05
Sb + As + Pb + Cr + Co + Cu + Mn + Ni + V	0,5

C expressed in ng/Nm³ (O_2 content 6 %). All average values measured over the sample period of a minimum of 6 hours and a maximum of 8 hours:

Pollutant	C
Dioxins and furans	0,1

II.3. Special provisions for industrial sectors not covered under II.1 or II.2 co-incinerating waste

II.3.1. *C — total emission limit values:*

C expressed in ng/Nm³. All average values measured over the sample period of a minimum of 6 hours and a maximum of 8 hours:

Pollutant	C
Dioxins and furans	0,1

C expressed in mg/Nm^3. All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours:

Pollutant	C
Cd + Tl	0,05
Hg	0,05

ANNEX III

Measurement techniques

1. Measurements for the determination of concentrations of air and water polluting substances have to be carried out representatively.
2. Sampling and analysis of all pollutants including dioxins and furans as well as reference measurement methods to calibrate automated measurement systems shall be carried out as given by CEN-standards. If CEN standards are not available, ISO standards, national or international standards which will ensure the provision of data of an equivalent scientific quality shall apply.
3. At the daily emission limit value level, the values of the 95 % confidence intervals of a single measured result shall not exceed the following percentages of the emission limit values:

Carbon monoxide:	10 %
Sulphur dioxide:	20 %
Nitrogen dioxide:	20 %
Total dust:	30 %
Total organic carbon:	30 %
Hydrogen chloride:	40 %
Hydrogen fluoride:	40 %.

ANNEX IV

Emission limit values for discharges of waste water from the cleaning of exhaust gases

Polluting substances	Emission limit values expressed in mass concentrations for unfiltered samples	
1. Total suspended solids as defined by Directive 91/271/EEC	95 % 30 mg/l	100 % 45 mg/l
2. Mercury and its compounds, expressed as mercury (Hg)	0,03 mg/l	
3. Cadmium and its compounds, expressed as cadmium (Cd)	0,05 mg/l	
4. Thallium and its compounds, expressed as thallium (Tl)	0,05 mg/l	
5. Arsenic and its compounds, expressed as arsenic (As)	0,15 mg/l	
6. Lead and its compounds, expressed as lead (Pb)	0,2 mg/l	
7. Chromium and its compounds, expressed as chromium (Cr)	0,5 mg/l	
8. Copper and its compounds, expressed as copper (Cu)	0,5 mg/l	
9. Nickel and its compounds, expressed as nickel (Ni)	0,5 mg/l	
10. Zinc and its compounds, expressed as zinc (Zn)	1,5 mg/l	
11. Dioxins and furans, defined as the sum of the individual dioxins and furans evaluated in accordance with Annex I	0,3 mg/l	

Until 1 January 2008, exemptions for total suspended solids may be authorised by the competent authority for existing incineration plants provided the permit foresees that 80 % of the measured values do not exceed 30 mg/l and none of them exceed 45 mg/l.

ANNEX V

AIR EMISSION LIMIT VALUES

(a) Daily average values

Total dust	10 mg/m³
Gaseous and vaporous organic substances, expressed as total organic carbon	10 mg/m³
Hydrogen chloride (HCl)	10 mg/m³
Hydrogen fluoride (HF)	1 mg/m³
Sulphur dioxide (SO_2)	50 mg/m³
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2) expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	200 mg/m³ (*)
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide for existing incineration plants with a nominal capacity of 6 tonnes per hour or less	400 mg/m³ (*)

(*) Until 1 January 2007 and without prejudice to relevant (Community) legislation the emission limit value for NO_x does not apply to plants only incinerating hazardous waste.

Exemptions for NO_x may be authorised by the competent authority for existing incineration plants:

— with a nominal capacity of 6 tonnes per hour, provided that the permit foresees the daily average values do not exceed 500 mg/m³ and this until 1 January 2008,

— with a nominal capacity of >6 tonnes per hour but equal or less than 16 tonnes per hour, provided the permit foresees the daily average values do not exceed 400 mg/m³ and this until 1 January 2010,

— with a nominal capacity of >16 tonnes per hour but <25 tonnes per hour and which do not produce water discharges, provided that the permit foresees the daily average values do not exceed 400 mg/m³ and this until 1 January 2008.

Until 1 January 2008, exemptions for dust may be authorised by the competent authority for existing incinerating plants, provided that the permit foresees the daily average values do not exceed 20 mg/m³.

(b) Half-hourly average values

	(100 %) A	(97 %) B
Total dust	30 mg/m³	10 mg/m³
Gaseous and vaporous organic substances, expressed as total organic carbon	20 mg/m³	10 mg/m³
Hydrogen chloride (HCl)	60 mg/m³	10 mg/m³
Hydrogen fluoride (HF)	4 mg/m³	2 mg/m³
Sulphur dioxide (SO_2)	200 mg/m³	50 mg/m³
Nitrogen monoxide (NO) and nitrogen dioxide (NO_2), expressed as nitrogen dioxide for existing incineration plants with a nominal capacity exceeding 6 tonnes per hour or new incineration plants	400 mg/m³ (*)	200 mg/m³ (*)

(*) Until 1 January 2007 and without prejudice to relevant Community legislation the emission limit value for NO_x does not apply to plants only incinerating hazardous waste.

Until 1 January 2010, exemptions for NO_2 may be authorised by the competent authority for existing incineration plants with a nominal capacity between 6 and 16 tonnes per hour, provided the half-hourly average value does not exceed 600 mg/m³ for column A or 400 mg/m³ for column B.

(c) All average values over the sample period of a minimum of 30 minutes and a maximum of 8 hours

Cadmium and its compounds, expressed as cadmium (Cd)		
Thallium and its compounds, expressed as thallium (Tl)	total 0,05 mg/m³	total 0,1 mg/m³ (*)
Mercury and its compounds, expressed as mercury (Hg)	0,05 mg/m³	0,1 mg/m³ (*)
Antimony and its compounds, expressed as antimony (Sb)		
Arsenic and its compounds, expressed as arsenic (As)		
Lead and its compounds, expressed as lead (Pb)		
Chromium and its compounds, expressed as chromium (Cr)		
Cobalt and its compounds, expressed as cobalt (Co)	total 0,5 mg/m³	total 1 mg/m³ (*)
Copper and its compounds, expressed as copper (Cu)		
Manganese and its compounds, expressed as manganese (Mn)		
Nickel and its compounds, expressed as nickel (Ni)		
Vanadium and its compounds, expressed as vanadium (V)		

(*) Until 1 January 2007 average values for existing plants for which the permit to operate has been granted before 31 December 1996, and which incinerate hazardous waste only.

These average values cover also gaseous and the vapour forms of the relevant heavy metal emissions as well as their compounds.

(d) Average values shall be measured over a sample period of a minimum of 6 hours and a maximum of 8 hours. The emission limit value refers to the total concentration of dioxins and furans calculated using the concept of toxic equivalence in accordance with Annex I.

Dioxins and furans	0,1 ng/m³

(e) The following emission limit values of carbon monoxide (CO) concentrations shall not be exceeded in the combustion gases (excluding the start-up and shut-down phase):

— 50 milligrams/m³ of combustion gas determined as daily average value;
— 150 milligrams/m³ of combustion gas of at least 95 % of all measurements determined as 10-minute average values or 100 mg/m³ of combustion gas of all measurements determined as half-hourly average values taken in any 24-hour period.

Exemptions may be authorised by the competent authority for incineration plants using fluidised bed technology, provided that the permit foresees an emission limit value for carbon monoxide (CO) of not more than 100 mg/m³ as an hourly average value.

(f) Member States may lay down rules governing the exemptions provided for in this Annex.

ANNEX VI

Formula to calculate the emission concentration at the standard percentage oxygen concentration

$$E_s = \frac{21 - O_s}{21 - O_m} \times E_m$$

E_s = calculated emission concentration at the standard percentage oxygen concentration

E_m = measured emission concentration

O_s = standard oxygen concentration

O_m = measured oxygen concentration

ANNEX II. EU LANDFILL LEGISLATION 1999

Consolidated TEXT

produced by the C O N S L E G system of the Office for Official Publications of the European Communities

---

CONSLEG: 1999L0031 — 20/11/2003

Number of pages: 22

Office for Official Publications of the European Communities

? B

COUNCIL DIRECTIVE 1999/31/EC
of 26 April 1999
on the landfill of waste

(OJ L 182, 16.7.1999, p. 1)

Amended by:

		Official Journal		
		No	page	date
? M 1	Regulation (EC) No 1882/2003 of the European Parliament and of the Council of 29 September 2003	L 284	1	31.10.2003

?**B**

COUNCIL DIRECTIVE 1999/31/EC
of 26 April 1999
on the landfill of waste

THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty establishing the European Community, and in particular Article 130s(1) thereof,

Having regard to the proposal from the Commission ([1]),

Having regard to the opinion of the Economic and Social Committee ([2]),

Acting in accordance with the procedure laid down in Article 189c of the Treaty ([3]),

1) Whereas the Council resolution of 7 May 1990 ([4]) on waste policy welcomes and supports the Community strategy document and invites the Commission to propose criteria and standards for the disposal of waste by landfill;

2) Whereas the Council resolution of 9 December 1996 on waste policy considers that, in the future, only safe and controlled landfill activities should be carried out throughout the Community;

3) Whereas the prevention, recycling and recovery of waste should be encouraged as should the use of recovered materials and energy so as to safeguard natural resources and obviate wasteful use of land;

4) Whereas further consideration should be given to the issues of incineration of municipal and non-hazardous waste, composting, biomethanisation, and the processing of dredging sludges;

5) Whereas under the polluter pays principle it is necessary, *inter alia,* to take into account any damage to the environment produced by a landfill;

6) Whereas, like any other type of waste treatment, landfill should be adequately monitored and managed to prevent or reduce potential adverse effects on the environment and risks to human health;

7) Whereas it is necessary to take appropriate measures to avoid the abandonment, dumping or uncontrolled disposal of waste; whereas, accordingly, it must be possible to monitor landfill sites with respect to the substances contained in the waste deposited there, whereas such substances should, as far as possible, react only in foreseeable ways;

8) Whereas both the quantity and hazardous nature of waste intended for landfill should be reduced where appropriate; whereas the handling of waste should be facilitated and its recovery enhanced; whereas the use of treatment processes should therefore be encouraged to ensure that landfill is compatible with the objectives of this Directive; whereas sorting is included in the definition of treatment;

9) Whereas Member States should be able to apply the principles of proximity and self-sufficiency for the elimination of their waste at Community and national level, in accordance with Council

1) OJ C 156, 24.5.1997, p. 10.
2) OJ C 355, 21.11.1997, p. 4.
3) Opinion of the European Parliament of 19 February 1998 (OJ C 80, 16.3.1998, p. 196), Council common position of 4 June 1998 (OJ C 333, 30.10.1998, p. 15) and Decision of the European Parliament of 3 February 1999 (OJ C 150, 28.5.1999, p. 78)
4) OJ C 122, 18.5.1990, p. 2.

?**B**

Directive 75/442/EEC of 15 July 1975 on waste ([1]) whereas the objectives of this Directive must be pursued and clarified through the establishment of an adequate, integrated network of disposal plants based on a high level of environmental protection;

10) Whereas disparities between technical standards for the disposal of waste by landfill and the lower costs associated with it might give rise to increased disposal of waste in facilities with low standards of environmental protection and thus create a potentially serious threat to the environment, owing to transport of waste over unnecessarily long distances as well as to inappropriate disposal practices;

11) Whereas it is therefore necessary to lay down technical standards for the landfill of waste at Community level in order to protect, preserve and improve the quality of the environment in the Community;

12) Whereas it is necessary to indicate clearly the requirements with which landfill sites must comply as regards location, conditioning, management, control, closure and preventive and protective measures to be taken against any threat to the environment in the short as well as in the long-term perspective, and more especially against the pollution of groundwater by leachate infiltration into the soil;

13) Whereas in view of the foregoing it is necessary to define clearly the classes of landfill to be considered and the types of waste to be accepted in the various classes of landfill;

14) Whereas sites for temporary storage of waste should comply with the relevant requirements of Directive 75/442/EEC;

15) Whereas the recovery, in accordance with Directive 75/442/EEC, of inert or non-hazardous waste which is suitable, through their use in redevelopment/restoration and filling-in work, or for construction purposes may not constitute a landfilling activity;

16) Whereas measures should be taken to reduce the production of methane gas from landfills, *inter alia,* in order to reduce global warming, through the reduction of the landfill of biodegradable waste and the requirements to introduce landfill gas control;

17) Whereas the measures taken to reduce the landfill of biodegradable waste should also aimat encouraging the separate collection of biodegradable waste, sorting in general, recovery and recycling;

18) Whereeas, because of the particular features of the landfill method of waste disposal, it is necessary to introduce a specific permit procedure for all classes of landfill in accordance with the general licensing requirements already set down in Directive 75/ 442/EEC and the general requirements of Directive 96/61/EC concerning integrated pollution prevention and control ([2]) whereas the landfill site's compliance with such a permit must be verified in the course of an inspection by the competent authority before the start of disposal operations;

19) Whereas, in each case, checks should be made to establish whether the waste may be placed in the landfill for which it is intended, in particular as regards hazardous waste;

20) Whereas, in order to prevent threats to the environment, it is necessary to introduce a uniformwaste acceptance procedure on the basis of a classification procedure for waste acceptable in the different categories of landfill, including in particular standardised limit values; whereas to that end a consistent and standardised systemof waste characterisation, sampling and

1) OJ L 194, 25.7.1975, p. 39. Directive as last amended by Commission Decision 96/350/EC (OJ L 135, 6.6.1996, p. 32).
2) OJ L 257, 10.10.1996, p. 26.

analysis must be established in time to facilitate implementation of this Directive; whereas the acceptance criteria must be particularly specific with regard to inert waste;

21) Whereas, pending the establishment of such methods of analysis or of the limit values necessary for characterisation, Member States may for the purposes of this Directive maintain or draw up national lists of waste which is acceptable or unacceptable for landfill, or define criteria, including limit values, similar to those laid down in this Directive for the uniformacceptance procedure;

22) Whereas for certain hazardous waste to be accepted in landfills for non-hazardous waste acceptance criteria should be developed by the technical committee;

23) Whereas it is necessary to establish common monitoring procedures during the operation and after-care phases of a landfill in order to indentify any possible adverse environmental effect of the landfill and take the appropriate corrective measures;

24) Whereas it is necessary to define when and how a landfill should be closed and the obligations and responsibility of the operator on the site during the after-care period;

25) Whereas landfill sites that have been closed prior to the date of transposition of this Directive should not be suject to its provisions on closure procedure;

26) Whereas the future conditions of operation of existing landfills should be regulated in order to take the necessary measures, within a specified period of time, for their adaptation to this Directive on the basis of a site-conditioning plan;

27) Whereas for operators of existing landfills having, in compliance with binding national rules equivalent to those of Article 14 of this Directive, already submitted the documentation referred to in Article 14(a) of this Directive prior to its entry into force and for which the competent authority authorised the continuation of their operation, there is no need to resubmit this documentation nor for the competent authority to deliver a new authorisation;

28) Whereas the operator should make adequate provision by way of a financial security or any other equivalent to ensure that all the obligations flowing fromthe permit are fulfilled, including those relating to the closure procedure and after-care of the site;

29) Whereas measures should be taken to ensure that the price charged for waste disposal in a landfill cover all the costs involved in the setting up and operation of the facility, including as far as possible the financial security or its equivalent which the site operator must provide, and the estimated cost of closing the site including the necessary after-care;

30) Whereas, when a competent authority considers that a landfill is unlikely to cause a hazard to the environment for longer than a certain period, the estimated costs to be included in the price to be charged by an operator may be limited to that period;

31) Whereas it is necessary to ensure the proper application of the provisions implementing this Directive throughout the Community, and to ensure that the training and knowledge acquired by landfill operators and staff afford themthe necessary skills;

32) Whereas the Commission must establish a standard procedure for the acceptance of waste and set up a standard classification of waste acceptable in a landfill in accordance with the committee procedure laid down in Article 18 of Directive 75/ 442/EEC;

33) Whereas adaptation of the Annexes to this Directive to scientific and technical progress and the standardisation of the monitoring, sampling

and analysis methods must be adopted under the same committee procedure;

?**B**

(34) Whereas the Member States must send regular reports to the Commission on the implementation of this Directive paying particular attention to the national strategies to be set up in pursuance of Article 5; whereas on the basis of these reports the Commission shall report to the European Parliament and the Council;

HAS ADOPTED THIS DIRECTIVE *Article*

1 **Overall**

objective

1. With a view to meeting the requirements of Directive 75/442/ EEC, and in particular Articles 3 and 4 thereof, the aimof this Directive is, by way of stringent operational and technical requirements on the waste and landfills, to provide for measures, procedures and guidance to prevent or reduce as far as possible negative effects on the environment, in particular the pollution of surface water, ground-water, soil and air, and on the global environment, including the greenhouse effect, as well as any resulting risk to human health, from landfilling of waste, during the whole life-cycle of the landfill.

2. In respect of the technical characteristics of landfills, this Directive contains, for those landfills to which Directive 96/61/EC is applicable, the relevant technical requirements in order to elaborate in concrete terms the general requirements of that Directive. The relevant requirements of Directive 96/61/EC shall be deemed to be fulfilled if the requirements of this Directive are complied with.

Article 2

Definiti

ons For the purposes of this Directive:

a) 'waste' means any substance or object which is covered by Directive 75/442/EEC;

b) 'municipal waste' means waste from households, as well as other waste which, because of its nature or composition, is similar to waste fromhousehold;

c) 'hazardous waste' means any waste which is covered by Article 1(4) of Council Directive 91/689/EEC of 12 December 1991 on hazardous waste ([1])

d) 'non-hazardous waste' means waste which is not covered by paragraph (c);

e) 'inert waste' means waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harmhuman health. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater;

f) 'underground storage' means a permanent waste storage facility in a deep geological cavity such as a salt or potassiummine;

g) 'landfill' means a waste disposal site for the deposit of the waste onto or into land (i.e. underground), including:

— internal waste disposal sites (i.e. landfill where a producer of waste is carrying out its own waste disposal at the place of production), and

([1]) OJ L 377, 31.12.1991, p. 20. Directive as last amended by Directive 94/31/ EC (OJ L 168, 2.7.1994, p. 28);1999L0031 — EN — 20.11.2003 — 001.001 — 6

?**B**

— a permanent site (i.e. more than one year) which is used for temporary storage of waste,

but excluding:

— facilities where waste is unloaded in order to permit its preparation for further transport for recovery, treatment or dispsal elsewhere, and

— stoarage of waste prior to recovery or treatment for a period less than three years as a general rule, or

— storage of waste prior to disposal for a period less than one year;

h) 'treatment' means the physical, thermal, chemical or biological processes, including sorting, that change the characteristics of the waste in order to reduce its volume or hazardous nature, facilitate its handling or enhance recovery;

i) 'leachate' means any liquid percolating through the deposited waste and emitted from or contained within a landfill;

j) 'landfill gas' means all the gases generated from the landfilled waste;

k) 'eluate' means the solution obtained by a laboratory leaching test;

l) 'operator' means the natural or legal person responsible for a landfill in accordance with the internal legislation of the Member State where the landfill is located; this person may change from the preparation to the after-care phase;

m) 'biodegradable waste' means any waste that is capable of under-going anaerobic or aerobic decomposition, such as food and garden waste, and paper and paperboard;

n) 'holder' means the producer of the waste or the natural or legal person who is in possession of it;

o) 'applicant' means any person who applies for a landfill permit under this Directive;

p) 'competent authority' means that authority which the Member States designate as responsible for performing the duties arising fromthis Directive;

q) 'liquid waste' means any waste in liquid form including waste waters but excluding sludge;

r) 'isolated settlement' means a settlement:

— with no more than 500 inhabitants per municipality or settlement and no more than five inhabitants per square kilometre and,

— where the distance to the nearest urban agglomeration with at least 250 inhabitants per square kilometre is not less than 50 km, or with difficult access by road to those nearest agglomerations, due to harsh meteorological conditions during a significant part of the year.

Article 3 **Scope**

1. Member States shall apply this Directive to any landfill as defined in Article 2(g).

2. Without prejudice to existing Community legislation, the following shall be excluded fromthe scope of this Directive:

— the spreading of sludges, including sewage sludges, and sludges resulting from dredging operations, and similar matter on the soil for the purposes of fertilisation or improvement,

— the use of inert waste which is suitable, in redevelopment/restoration and filling-in work, or for construction purposes, in landfills,

— the deposit of non-hazardous dredging sludges alongside small waterways fromwhere they have been dredged out and of non-hazardous sludges in surface water including the bed and its sub soil,

?**B**

— the deposit of unpolluted soil or of non-hazardous inert waste resulting fromprospecting and extraction, treatment, and storage of mineral resources as well as from the operation of quarries.

3. Without prejudice to Directive 75/442/EEC Member States may declare at their own option, that the deposit of non-hazardous waste, to be defined by the committee established under Article 17 of this Directive, other than inert waste, resulting fromprospecting and extraction, treatment and storage of mineral resources as well as from the operation of quarries and which are deposited in a manner preventing environmental pollution or harm to human health, can be exempted fromthe provisions in Annex I, points 2, 3.1, 3.2 and 3.3 of this Directive.

4. Without prejudice to Directive 75/442/EEC Member States may declare, at their own option, parts or all of Articles 6(d), 7(i), 8(a)(iv), 10, 11(1)(a), (b) and (c), 12(a) and (c), Annex I, points 3 and 4, Annex II (except point 3, level 3, and point 4) and Annex III, points 3 to 5 to this Directive not applicable to:

a) landfill sites for non-hazardous or inert wastes with a total capacity not exceeding 15 000 tonnes or with an annual intake not exceeding 1 000 tonnes serving islands, where this is the only land-fill on the island and where this is exclusively destined for the disposal of waste generated on that island. Once the total capacity of that landfill has been used, any new landfill site established on the island shall comply with the requirements of this Directive;

b) landfill sites for non-hazardous or inert waste in isolated settlements if the landfill site is destined for the disposal of waste generated only by that isolated settlement.

Not later than two years after the date laid down in Article 18(1), Member States shall notify the Commission of the list of islands and isolated settlements that are exempted. The Commission shall publish the list of islands and isolated settlements.

5. Without prejudice to Directive 75/442/EEC Member States may declare, at their own option, that underground storage as defined in Article 2(f) of this Directive can be exempted from the provisions in Article 13(d) and in Annex I, point 2, except first indent, points 3 to 5 and in Annex III, points 2, 3 and 5 to this Directive.

Article 4

Classes of landfill

Each landfill shall be classified in one of the following classes:

— landfill for hazardous waste,

— landfill for non-hazardous waste,

— landfill for inert waste.

Article 5

Waste and treatment not acceptable in landfills

1. Member States shall set up a national strategy for the implementation of the reduction of biodegradable waste going to landfills, not later than two years after the date laid down in Article 18(1) and notify the Commission of this strategy. This strategy should include measures to achieve the targets set out in paragraph 2 by means of in particular, recycling, composting, biogas production or materials/energy recovery. Within 30 months of the date laid down in Article 18(1) the Commission shall provide the European Parliament and the Council with a report drawing together the national strategies.

2. This strategy shall ensure that:

(a) not later than five years after the date laid down in Article 18(1), biodegradable municipal waste going to landfills must be reduced to 75 % of the total amount (by weight) of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which standardised Eurostat data is available

?**B**

b) not later than eight years afte the date laid down in Article 18(1), biodegradable municipal waste going to landfills must be reduced to 50 % of the total amount (by weight) of biodegradable municipal waste produced in 1995 or the latest year before 1995 for which stadardised Eurostat data is available;

c) not later than 15 years after the date laid down in Article 18(1), biodegradable municipal waste going to landfills must be reduced to 35 % of the total amount (by weight) of biodegradable municipal waste produced in 1995 or the lates year before 1995 for which standardised Eurostat data is available.

Two years before the date referred to in paragraph (c) the Council shall reexamine the above target, on the basis of a report from the Commission on the practical experience gained by Member States in the pursuance of the targets laid down in paragraphs (a) and (b) accompanied, if appropriate, by a proposal with a view to confirming or amending this target in order to ensure a high level of environmental protection.

Member States which in 1995 or the latest year before 1995 for which standardised EUROSTAT data is available put more than 80 % of their collected municipal waste to landfill may postpone the attainment of the targets set out in paragraphs (a), (b), or (c) by a period not exceeding four years. Member States intending to make use of this provision shall inform in advance the Commission of their decision. The Commission shall inform other Member States and the European Parliament of these decisions.

The implementation of the provisions set out in the preceding subparagraph may in no circumstances lead to the attainment of the target set out in paragraph (c) at a date later than four years after the date set out in paragraph (c).

3. Member States shall take measures in order that the following wastes are not accepted in a landfill:

a) liquid waste;

b) waste which, in the conditions of landfill, is explosive, corrosive, oxidising, highly flammable or flammable, as defined in Annex III to Directive 91/689/EEC;

c) hospital and other clinical wastes arising frommedical or oveterinary establishments, which are infectious as defined (property H9 in Annex III) by Directive 91/689/EEC and waste falling within category 14 (Annex I.A) of that Directive.

d) whole used tyres fromtwo years fromthe date laid down in Article 18(1), excluding tyres used as engineering material, and shredded used tyres five years fromthe date laid down in Article 18(1) (excluding in both instances bicylce tyres and tyres with an outside diameter above 1 400 mm);

e) any other type of waste which does not fulfil the acceptance criteria determined in accordance with Annex II.

4. The dilution of mixture of waste solely in order to meet the waste acceptance criteria is prohibited.

Article 6

Waste to be accepted in the different classes of landfill Member

States shall take measures in order that:

a) only waste that has been subject to treatment is landfilled. This provision may not apply to inert waste for which treatment is not technically feasible, nor to any other waste for which such treatment does not contribute to the objectives of this Directive, as set out in Article 1, by reducing the quantity of the waste or the hazards to human health or the environment;

b) only hazardous waste that fulfils the criteria set out in accordance with Annex II is assigned to a hazardous landfill;

?**B**

(c) landfill for non-hazardous waste may be used for:

i) municipal waste;

ii) non-hazardous waste of any other origin, which fulfil the criteria for the acceptance of waste at landfill for non-hazardous waste set out in accordance with Annex II;

iii) stable, non-reactive hazardous wastes (e.g. solidified, vitrified), with leaching behaviour equivalent to those of the non-hazardous wastes referred to in point (ii), which fulfil the relevant acceptance criteria set out in accordance with Annex II. These hazarouds wastes shall not be deposited in cells destined for biodegradable non-hazardous waste,

(d) inert waste landfill sites shall be used only for inert waste. *Article 7*

Application for a permit

Member States shall take measures in order that the application for a landfill permit must contain at least particulars of the following:

a) the identity of the applicant and of the operator when they are different entities;

b) the description of the types and total quantity of waste to be deposited;

c) the proposed capacity of the disposal site;

d) the description of the site, including its hydrogeological and geological characteristics;

e) the proposed methods for pollution prevention and abatement;

f) the proposed operation, monitoring and control plan;

g) the proposed plan for the closure and after-care procedures;

h) where an impact assessment is required under Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment ([1]), the information provided by the developer in accordance with Article 5 of that Directive;

i) the financial security by the applicant, or any other equivalent provision, as required under Article 8(a)(iv) of this Directive.

Following a successful application for a permit, this information shall be made available to the competent national and Community statistical authorities when requested for statistical purposes.

Article 8

Conditions of the permit Member States shall take measures in order that:

(a) the competent authority does not issue a landfill permit unless it is satisfied that:

i) without prejudice to Article 3(4) and (5), the landfill project complies with all the relevant requirements of this Directive, including the Annexes;

ii) the management of the landfill site will be in the hands of a natural person who is technically competent to manage the site; professional and technical development and training of landfill operators and staff are provided;

iii) the landfill shall be operated in such a manner that the necessary measures are taken to prevent accidents and limit their consequences;

iv) adequate provisions, by way of a financial security or any other

equivalent, on the basis of modalities to be decided by

([1]) OJ L 175, 5.7.1985, p. 40. Directive as amended by Directive 97/11/EC (OJ L 73, 14.3.1997, p. 5).1999L0031 — EN — 20.11.2003 — 001.001 — 10

?**B**

Member States, has been or will be made by the applicant prior to the commencement of disposal operations to ensure that the obligations (including after-care provisions) arising under the permit issued under the provisions of this Directive are discharged and that the closure procedures required by Article 13 are followed. This security or its equivalent shall be kept as long as required by maintenance and after-care operation of the site in accordance with Article 13(d). Member States may declare, at their own option, that this point does not apply to landfills for inert waste;

b) the landfill project is in line with the relevant waste management plan or plans referred to in Article 7 of Directive 75/442/EEC;

c) prior to the commencement of disposal operations, the competent authority shall inspect the site in order to ensure that it complies with the relevant conditions of the permit. This will not reduce in any way the responsibility of the operator under the conditions of the permit.

Article 9

Content of the permit

Specifying and supplementing the provisions set out in Article 9 of Directive 75/442/EEC and Article 9 of Directive 96/61/EC, the landfill permit shall state at least the following:

a) the class of the landfill;

b) the list of defined types and the total quantity of waste which are authorised to be deposited in the landfill;

c) requirements for the landfill preparations, landfilling operations and monitoring and control procedures, including contingency plans (Annex III, point 4.B), as well as provisional requirements for the closure and after-care operations;

d) the obligation on the applicant to report at least annually to the competent authority on the types and quantities of waste disposed of and on the results of the monitoring programme as required in Articles 12 and 13 and Annex III.

Article 10

Cost of the landfill of waste

Member States shall take measures to ensure that all of the costs involved in the setting up and operation of a landfill site, including as far as possible the cost of the financial security or its equivalent referred to in Article 8(a)(iv), and the estimated costs of the closure and after-care of the site for a period of at least 30 years shall be covered by the price to be charged by the operator for the disposal of any type of waste in that site. Subject to the requirements of Council Directive 90/313/EEC of 7 June 1990 on the freedomof access to information on the environment ([1])Member States shall ensure transparency in the collection and use of any necessary cost information.

Article 11

Waste acceptance procedures

1. Member States shall take measures in order that prior to accepting the waste at the landfill site:

(a) before or at the time of delivery, or of the first in a series of deliveries, provided the type of waste remains unchanged, the holder or the operator can show, by means of the appropraite documentation, that the waste in

question can be accepted at that site according to the conditions set in the permit, and that it fulfils the acceptance criteria set out in Annex II;

([1]) OJ L 158, 23.6.1990, p. 56.

?**B**

(b) the following reception procedures are respected by the operator:

— checking of the waste documentation, including those documents required by Article 5(3) of Directive 91/689/EEC and, where they apply, those required by Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community ([1]);

— visual inspection of the waste at the entrance and at the point of deposit and, as appropriate, verification of conformity with the description provided in the documentation submitted by the holder. If representative samples have to be taken in order to implement Annex II, point 3, level 3, the results of the analyses shall be kept and the sampling shall be made in conformity with Annex II, point 5. These samples shall be kept at least one month;

— keeping a register of the quantities and characteristics of the waste deposited, indicating origin, date of delivery, identity of the producer or collector in the case of municipal waste, and, in the case of hazardous waste, the precise location on the site. This information shall be made available to the competent national and Community statistical authorities when requested for statistical purposes;

c) the operator of the landfill shall always provide written acknowledgement of receipt of each delivery acepted on the site;

d) without prejudice to the provisions of Regulation (EEC) No 259/ 93, if waste is not accepted at a landfill the operator shall notify without delay the competent authority of the non-acceptance of the waste.

2. For landfill sites which have been exempted from provisions of this Directive by virtue of Article 3(4) and (5), Member States shall take the necessary measures to provide for:

— regular visual inspection of the waste at the point of deposit in order to ensure that only non-hazardous waste fromthe island or the isolated settlement is accepted at the site; and

— a register on the quantities of waste that are deposited at the site be kept.

Member States shall ensure that information on the quantities and, where possible, the type of waste going to such exempted sites forms part of the regular reports to the Commission on the implementation of the Directive.

Article 12

Control and monitoring procedures in the operational phase

Member States shall take measures in order that control and monitoring procedures in the operational phase meet at least the following requirements:

a) the operator of a landfill shall carry out during the operational phase a control and monitoring programme as specified in Annex III;

b) the operator shall notify the competent authority of any significant adverse environmental effects revealed by the control and monitoring procedures and follow the decision of the competent authority on the nature and timing of the corrective measures to be taken. These measures shall be undertaken at the expense of the operator.

At a frequency to be determined by the competent authority, and in any event at least once a year, the operator shall report, on the basis of aggregated data, all monitoring results to the competent authorities for the purpose of demonstrating compliance with

?**B**

permit conditions and increasing the knowledge on waste behaviour in the landfills;

(c) the quality control of the analytical operations of the control and monitoring procedures and/or of the analyses referred to in Article 11(1)(b) are carried out by competent laboratories.

Article 13

Closure and after-care procedures

Member States shall take measures in order that, in accordance, where appropriate, with the permit:

(a) a landfill or part of it shall start the closure procedure:

i) when the relevant conditions stated in the permit are met; or

ii) under the authorisation of the competent authority, at the request of the operator; or

iii) by reasoned decision of the competent authority;

(b) a landfill or part of it may only be considered as definitely closed after the competent authority has carried out a final on-site inspection, has assessed all the reports submitted by the operator and has communicated to the operator its approval for the closure. This shall not in any way reduce the responsibility of the operator under the conditions of the permit;

(c) after a landfill has been definitely closed, the operator shall be responsible for its maintenance, monitoring and control in the after-care phase for as long as may be required by the competent authority, taking into account the time during which the landfill could present hazards.

The operator shall notify the competent authority of any significant adverse environmental effects revealed by the control procedures and shall follow the decision of the competent authority on the nature and timing of the corrective measures to be taken;

(d) for as long as the competent authority considers that a landfill is likely to cause a hazard to the environment and without prejudice to any Community or national legislation as regards liability of the waste holder, the operator of the site shall be responsible for monitoring and analysing landfill gas and leachate fromthe site and the groundwater regime in the vicinity of the site in accordance with Annex III.

Article 14

Existing landfill sites

Member States shall take measures in order that landfills which have been granted a permit, or which are already in operation at the time of transposition of this Directive, may not continue to operate unless the steps outlined below are accomplished as soon as possible and within eight years after the date laid down in Article 18(1) at the latest:

a) with a period of one year after the date laid down in Article 18(1), the operator of a landfill shall prepare and present to the competent authorities, for their approval, a conditioning plan for the site including the particulars listed in Article 8 and any corrective measures which the operator considers will be needed in order to comply with the requirements of this Directive with the exception of the requirements in Annex I, point 1;

b) following the presentation of the conditioning plan, the competent authorities shall take a definite decision on whether operations may continue on the basis of the said conditioning plan and this Directive. Member States shall take the necessary measures to close down as soon as possible, in accordance with Article 7(g) and 13, sites which have not been granted, in accordance with Article 8, a permit to continue to

operate;

c) on the basis of the approved site-conditioning plan, the competent authority shall authorise the necessary work and shall lay down a

?**B**

transitional period for the completion of the plan. Any existing landfill shall comply with the requirements of this Directive with the exception of the requirements in Annex I, point 1 within eight years after the date laid down in Article 18(1);

(d) (i) within one year after the date laid down in Article 18(1), Articles 4, 5, and 11 and Annex II shall apply to landfills for hazardous waste;

(ii) within three years after the date laid down in Article 18(1), Article 6 shall apply to landfills for hazardous waste.

Article 15

Obligation to report

At intervals of three years Member States shall send to the Commission a report on the implementation of this Directive, paying particular attention to the national strategies to be set up in pursuance of Article 5. The report shall be drawn up on the basis of a questionnaire or outline drafted by the Commission in accordance with the procedure laid down in Article 6 of Directive 91/692/EEC ([1]) The questionnaire or outline shall be sent to Member States six months before the start of the period covered by the report. The report shall be sent to the Commission within nine months of the end of the three-year period covered by it.

The Commission shall publish a Community report on the implementation of this Directive within nine months of receiving the reports from the Member States.

Article

16

Commi

ttee

Any amendments necessary for adapting the Annexes to this Directive to scientific and technical progress and any proposals for the standardisation of control, sampling and analysis methods in relation to the landfill of waste shall be adopted by the Commission, assisted by the Committee established by Article 18 of Directive 75/442/EEC and in accordance with the procedure set out in Article 17 of this Directive. Any amendments to the Annexes shall only be made in line with the principles laid down in this Directive as expressed in the Annexes. To this end, as regards Annex II, the following shall be observed by the Committee: taking into account the general principles and general procedures for testing and acceptance criteria as set out in Annex II, specific criteria and/or test methods and associated limit values should be set for each class of landfill, including if necessary specific types of landfill within each class, including underground storage. Proposals for the standardisation of control, sampling and analysis methods in relation to the Annexes of this Directive shall be adopted by the Commission, assisted by the Committee, within two years after the entry into force of this Directive.

The Commission, assisted by the Committee, will adopt provisions for the harmonisation and regular transmission of the statistical date referred to in Articles 5, 7 and 11 of this Directive, within two years after the entry into force of this Directive, and for the amendments of such provisions when necessary.

([1]) OJ L 377, 31.12.1991, p. 48.

?**M1**

Article 17

1. The Commission shall be assisted by a committee.

2. Where reference is made to this Article, Articles 5 and 7 of Decision 1999/468/EC ([1]) shall apply, having regard to the provisions of Article 8 thereof.

The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.

3. The Committee shall adopt its rules of procedure.

?**B**

Article 18

Transposition

1. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive not later than two years after its entry into force. They shall forthwith inform the Commission thereof.

When Member States adopt these measures, they shall contain a reference to this Directive or shall be accompanied by such reference on the occasion of their official publication. The methods of making such a reference shall be laid down by Member States.

2. Member States shall communicate the texts of the provisions of national law which they adopt in the field covered by this Directive to the Commission.

Article 19

Entry into force

This Directive will enter into force on the day of its publication in the *Official Journal of the European Communities.*

Article

20

Addres

sees

This Directive is addressed to the Member States.

([1]) Council Decision 1999/468/EC of 28 June 1999 laying down the procedures for the exercise of implementing powers conferred on the Commission (OJ L 184, 17.7.1999, p. 23).

?B*ANNEX I*

GENERAL REGUIREMENTS FOR ALL CLASSES OF LANDFILLS

1. **Location**

1.1. The location of a landfill must take into consideration requirements relating to:

a) the distances fromthe boundary of the site to residential and recreation areas, waterways, water bodies and other agricultural or urban sites;
b) the existence of groundwater, coastal water or nature protection zones in the area;
c) the geological and hydrogeological conditions in the area;

d) the risk of flooding, subsidence, landslides or avalanches on the site;

e) the protection of the nature or cultural patrimony in the area.

1.2. The landfill can be authorised only if the characteristics of the site with respect to the abovementioned requirements, or the corrective measures to be taken, indicate that the landfill does not pose a serious environmental risk.

2. **Water control and leachate management**

Appropriate measures shall be taken, with respect to the characteristics of the landfill and the meteorological conditions, in order to:

— control water fromprecipitations entering into the landfill body,
— prevent surface water and/or groundwater fromentering into the land-filled waste,
— collect contaminated water and leachate. If an assessment based on consideration of the location of the landfill and the waste to be accepted shows that the landfill poses no potential hazard to the environment, the competent authority may decide that this provision does not apply,
— treat contaminated water and leachate collected from the landfill to the appropriate standard required for their discharge.

The above provisions may not apply to landfills for inert waste.

3. **Protection of soil and water**

3.1. A landfill must be situated and designed so as to meet the necessary conditions for preventing pollution of the soil, groundwater or surface water and ensuring efficient collection of leachate as and when required according to Section 2. Protection of soil, groundwater and surface water is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase and by the combination of a geological barrier and a bottomliner during the operational/active phase and by the combination of a geological barrier and a top liner during the passive phase/post closure.

3.2. The geological barrier is determined by geological and hydrogeological conditions below and in the vicinity of a landfill site providing sufficient attenuation capacity to prevent a potential risk to soil and groundwater.

The landfill base and sides shall consist of a mineral layer which satisfies permeability and thickness requirements with a combined effect in terms of protection of soil, groundwater and surface water at least equivalent to the one resulting fromthe following requirements:

— landfill for hazardous waste: K <_ 1,0 × 10- 9 m/s; thickness ≥ 5 m,
— landfill for non-hazardous waste: K <_ 1,0 × 10- 9 m/s; thickness ≥ 1m,
— landfill for inert waste: K <_ 1,0 × 10- 7 m/s; thickness ≥ 1 m,
,m/s: meter/second.

Where the geological barrier does not naturally meet the above conditions it can be completed artificially and reinforced by other means giving equivalent protection. An artificially established geological barrier should be no less than 0,5 meters thick.

3.3. In addition to the geological barrier described above a leachate collection and sealing systemmust be added in accordance with the following principles so as to ensure that leachate accumulation at the base of the landfill is kept to a minimum:

?**B**

Leachate collection and bottom sealing

Landfill category	non hazardous	hazardous
Artificial sealing liner	required	required
Drainage layer >_ 0,5 mr		

Member States may set general or specific requirements for inert waste landfills and for the characteristics of the abovementioned technical means.

If the competent authority after a consideration of the potential hazards to the environment finds that the prevention of leachate formation is necessary, a surface sealing may be prescribed. Recommendations for the surface sealing are as follows:

Landfill category	non hazardous	hazardous
Gas drainage layer	required	not required
Artificial sealing liner	not required	required
Impermeable mineral layer	required	required
Drainage layer > 0,5 mrequired	required	required
Top soil cover > 1 mrequired	required. d	required.

3.4. If, on the basis of an assessment of environmental risks taking into account, in particular, Directive 80/68/EEC ([1]), the competent authority has decided, in accordance with Section 2 ('Water control and leachate management'), that collection and treatment of leachate is not necessary or it has been established that the landfill poses no potential hazard to soil, groundwater or surface water, the requirements in paragraphs 3.2 and 3.3 above may be reduced accordingly. In the case of landfills for inert waste these requirements may be adapted by national legislation.

3.5. The method to be used for the determination of the permeability coefficient for landfills, in the field and for the whole extension of the site, is to be developed and approved by the Committee set up under Article 17 of this Directive.

4. Gas control

4.1. Appropriate measures shall be taken in order to control the accumulation and migration of landfill gas (Annex III).

4.2. Landfill gas shall be collected fromall landfills receiving biodegradable waste and the landfill gas must be treated and used. If the gas collected cannot be used to produce energy, it must be flared.

4.3. The collection, treatment and use of landfill gas under paragraph 4.2 shall be carried on in a manner which minimises damage to or deterioration of the environment and risk to human health.

5. Nuisances and hazards

Measures shall be taken to minimise nuisances and hazards arising from the landfill through:

— emissions of odours and dust,
— wind-blown materials,
— noise and traffic,
— birds, vermin and insects,
— formation and aerosols,
— fires.

The landfill shall be equipped so that dirt originating fromthe site is not dispersed onto public roads and the surrounding land.

(1) OJ L 20, 26.1.1980, p. 43. Directive as last amended by Directive 91/692/EEC (OJ L 377, 31.12.1991, p. 48).

?B

6. Stability

The emplacement of waste on the site shall take place in such a way as to ensure stability of the mass of waste and associated structures, particularly in respect of avoidance of slippages. Where an artificial barrier is established it must be ascertained that the geological substratum, considering the morphology of the landfill, is sufficiently stable to prevent settlement that may cause damage to the barrier.

7. Barriers

The landfill shall be secured to prevent free access to the site. The gates shall be locked outside operating hours. The systemof control and access to each facility should contain a programme of measures to detect and discourage illegal dumping in the facility.

?B

ANNEX I

WASTE ACCEPTANCE CRITERIA ANDPROCEDURES

1. **Introduction**

This Annex describes:

— general principles for acceptance of waste at the various classes of land-fills. The future waste classification procedure should be based on these principles,

— guidelines outlining preliminary waste acceptance procedures to be followed until a uniformwaste classification and acceptance procedure has been developed. This procedure will, together with the relevant sampling procedures, be developed by the technical Committee referred to in Article 16 of this Directive. The technical Committee shall develop criteria which have to be fulfilled for certain hazardous waste to be accepted in landfills for non-hazardous waste. These criteria should, in particular, take into account the short, medium and long term leaching behaviour of such waste. These criteria shall be developed within two years of the entry into force of this Directive. The technical Committee shall also develop criteria which have to be fulfilled for waste to be accepted in underground storage. These criteria must take into account, in particular, that the waste is not to be expected to react with each other and with the rock.

This work by the technical Committee, with the exception of proposals for the standardisation of control, sampling and analysis methods in relation to the Annexes of this Directive which shall be adopted within two years after the entry into force of this Directive, shall be completed within three years fromthe entry into force of this Directive and must be carried out having regard to the objectives set forth in Article 1 of this Directive.

2. **General principles**

The composition, leachability, long-term behaviour and general properties of a waste to be landfilled must be known as precisely as possible. Waste acceptance at a landfill can be based either on lists of accepted or refused waste, defined by nature and origin, and on waste analysis methods and limit values for the properties of the waste to be accepted. The future waste acceptance procedures described in this Directive shall as far as possible be based on standardised waste analysis methods and limit values for the properties of waste to be accepted.

Before the definition of such analysis methods and limit values, Member States should at least set national lists of waste to be accepted or refuses at each class of landfill, or defined the criteria required to be on the lists. In order to be accepted at a particular class of landfill, a type of waste must be on the relevant national list or fulfil criteria similar to those required to be on the list. These lists, or the equivalent criteria, and the analysis methods and limit values shall be sent to the Commission within six months of the transposition of this Directive or whenever they are adopted at national level.

These lists or acceptance criteria should be used to establish site specific lists, i.e. the list of accepted waste specified in the permit in accordance with Article 9 of this Directive.

The criteria for acceptance of waste on the reference lists or at a class of landfill may be based on other legislation and/or on waste properties.

Criteria for acceptance at a specific class of landfill must be derived from considerations pertaining to:

— protection of the surrounding environment (in particular groundwater and surface water),

— protection of the environmental protection systems (e.g. liners and leachate treatment systems),

— protection of the desired waste-stabilisation processes within the landfill,

— protection against human-health hazards.

Examples of waste property-based criteria are:

— requirements on knowledge of total composition,

— limitations on the amount of organic matter in the waste,

— requirements or limitations on the biodegradability of the organic waste components,

— limitations on the amount of specified, potentially harmful/hazardous components (in relation to the abovementioned protection criteria),

?**B**

— limitations on the potential and expected leachability of specified, potentially harmful/hazardous components (in relation to the abovementioned protection criteria),

— ecotoxicological properties of the waste and the resulting leachate.

The property-based criteria for acceptance of waste must generally be most extensive for inert waste landfills and can be less extensive for non-hazardous waste landfills and least extensive for hazardous waste landfills owing to the higher environmental protection level of the latter two.

3. General procedures for testing and acceptance of waste

The general characterisation and testing of waste must be based on the following three-level hierarchy:

Level 1: *Basic characterisation.* This constitutes a thorough determination, according to standardised analysis and behaviour-testing methods, of the short and long-term leaching behaviour and/or characteristic properties of the waste.

Level 2: *Compliance testing.* This constitutes periodical testing by simpler standardised analysis and behaviour-testing methods to determine whether a waste complies with permit conditions and/or specific reference criteria. The tests focus on key variables and behaviour identified by basic characterisation.

Level 3: *On-site verification.* This constitutes rapid check methods to confirmthat a waste is the same as that which has been subjected to compliance testing and that which is described in the accompanying documents. It may merely consist of a visual inspection of a load of waste before and after unloading at the landfill site.

A particular type of waste must normally be characterised at Level 1 and pass the appropriate criteria in order to be accepted on a reference list. In order to remain on a site-specific list, a particular type of waste must a regular intervals (e.g. annually) be tested at Level 2 and pass the appropriate criteria. Each waste load arriving at the gate of a landfill must be subjected to Level 3 verification.

Certain waste types may be exempted permanently to temporarily from testing at Level 1. This may be due to impracticability to testing, to unavailability of appropriate testing procedures and acceptance criteria or to overriding legislation.

4. Guidelines for preliminary waste acceptance procedures

Until this Annex is fully completed only Level 3 testing is mandatory and Level 1 and Level 2 applied to the extent possible. At this preliminary stage waste to be accepted at a particular class of landfill must either be on a restrictive national or site-specific list for that class of landfill or fulfil criteria similar to those required to get on the list.

The following general guidelines may be used to set preliminary criteria for acceptance of waste at the three major classes of landfill or the corresponding lists.

Inert waste landfills: only inert waste as defined in Article 2(e) can be accepted on the list.

Non-hazardous waste landfills: in order to be accepted on the list a waste type must not be covered by Directive 91/689/EEC.

Hazardous waste landfills: a preliminary rough list for hazardous waste land-fills would consist of only those waste types covered by Directive 91/689/ EEC. Such waste types should, however not be accepted on the list without prior treatment if they exhibit total contents or leachability of potentially hazardous components that are high enough to constitute a short-term occupational or environmental risk or to prevent sufficient waste stabilisation within the projected lifetime of the landfill.

5. Sampling of waste

Sampling of waste may pose serious problems with respect to representation and techniques owing to the heterogeneous nature of many wastes. A European standard for sampling of waste will be developed. Until this standard is approved by Member States in accordance with Article 17 of this Directive, the Member States may apply national standards and procedures.

?**B**

ANNEXIII

CONTROL ANDMONITORING PROCEDURES IN OPERATION AND AFTER-CARE PHASES

1. **Introduction**

The purpose of this Annex is to provide the minimum procedures for monitoring to be carried out to check:

— that waste has been accepted to disposal in accordance with the criteria set for the category of landfill in question,

— that the processes within the landfill proceed as desired,

— that the environmental protection systems are functioning fully as intended,

— that the permit conditions for the landfill are fulfilled.

2. Meteorological data

Under their reporting obligation (Article 15), Member States should supply data on the collection method for meteorological data. It us up to Member States to decide how the data should be collected *(in situ,* national meteorological network, etc.).

Should Member States decide that water balances are an effective tool for evaluating whether leachate is building up in the landfill body or whether the site is leaking, it is recommended that the following data are collected from monitoring at the landfill or from the nearest meteorological station, as long as required by the competent authority in accordance with Article 13(c) of this Directive:

	Operation phase	After-care phase
1.1. Volume of precipitation	daily	daily, added to monthly values
1.2. Temperature (min., max., 14.00 h CET)	daily	monthly average
1.3. Direction and force of prevailing wind	daily	not required
1.4. Evaporation (lysimeter) ([1])	daily	daily, added to monthly values
1.5. Atmospheric humidity (14.00 h CET)	daily	monthly average

([1]) Or through other suitable methods.

3. Emission data: water, leachate and gas control

Sampling of leachate and surface water if present must be collected at representative points. Sampling and measuring (volume and composition) of leachate must be performed separately at each point at which leachate is discharged fromthe site. Reference: general guidelines on sampling technology, ISO 5667-2 (1991).

Monitoring of surface water is present shall be carried out at not less than two points, one upstreamfromthe landfill and one downstream.

Gas monitoring must be representative for each section of the landfill. The frequency of sampling and analysis is listed in the following table. For leachate and water, a sample, representative of the average composition, shall be taken for monitoring.

The frequency of sampling could be adapted on the basis of the morphology of the landfill waste (in tumulus, buried, etc). This has to be specified in the permit.

2.1. Leachate volume
2.2. Leachate composition ([2])
2.3. Volume and composition of surface water ([7])

monthly ([1]) ([3])quarterly ([3]) quarterly ([3])

	Operating phase	After-care phase ([3])
	every six months	every six months every six months

?**B**Operating phase	After-care phase ([3])
2.4. Potential gas emissions and atmospheric pres monthly ([3])([5])	every six months ([6])sure ([4])(CH_4, CO_2, O_2, H_2S, H_2 etc.)

The frequency of sampling could be adapted on the basis of the morphology of the landfill waste (in tumulus, buried, etc.). This has to be specified in the permit.
The parameters to be measured and the substances to be analysed vary according to the composition of the waste deposited; they must be laid down in the permit document and reflect the leaching characteristics of the wastes. If the evaluation of data indicates that longer intervals are equally effective, they may be adapted. For leachates, conductivity must always be measured at least once a year.
Thease measurements are related mainly to the content of organic material in the waste.
CH_4, CO_2, O_2, regularly, other gases as required, according to the composition of the waste deposited, with a view to reflecting its leaching properties.
Efficiency of the gas extraction systemmust be checked regularly.
On the basis of the characteristics of the landfill site, the competent authority may determine that these measurements are not required, and will report accordingly in the way laid down in Article 15 of the Directive.2.1 and 2.2 apply only where leachate collection takes place (see Annex I(2)).

4. **Protection of groundwater**

A. Sampling

The measurements must be such as to provide information on ground-water likely to be affected by the discharging of waste, with at least one measuring point in the groundwater inflow region and two in the outflow region. This number can be increased on the basis of a specific hydrogeological survey and the need for an early identification of accidental leachate release in the groundwater.

Sampling must be carried out in at least three locations before the filling operations in order to establish reference values for future sampling. Reference: Sampling Groundwaters, ISO 5667, Part 11, 1993.

B. Monitoring

The parameters to be analysed in the samples taken must be derived from the expected composition of the leachate and the groundwater quality in the area. In selecting the parameters for analysis account should be taken of mobility in the groundwater zone. Parameters could include indicator parameters in order to ensure an early recognition of change in water quality ([1]).

	Operation phase	After-care phase
Level of groundwater	every six months ([1])	every six months ([1])
Groundwater composition	site-specific frequency ([2])([3])	site-specific frequency ([2])([3])

1) If there are fluctuating groundwater levels, the frequency must be increased.
2) The frequency must be based on possibility for remedial actions between two samplings if a trigger level is reached, i.e. the frequency must be determined on the basis of knowledge and the evaluation of the velocity of groundwater flow.
3) When a trigger level is reached (see C), verification is necessary by repeating the sampling. When the level has been confirmed, a contingency plan (laid down in the permit) must be followed.

C. Trigger levels

Significant adverse environmental effects, as referred to in Articles 12 and 13 of this Directive, should be considered to have occurred in the case of groundwater, when an analysis of a groundwater sample shows a significant change in water quality. A trigger level must be determined taking account of the specific hydrogeological formations in the location of the landfill and groundwater quality. The trigger level must be laid down in the permit whenever possible.

The observations must be evaluated by means of control charts with established control rules and levels for each downgradient well. The control levels must be determined from local variations in groundwater quality.

([1]) Recommended parameters: ph, TOC, phenols, heavy metals, fluoride, AS, oil/hydrocarbons.

?**B**

5. **Topography of the site: data on the landfill body**

	Operating phase	After-care phase
5.1. Structure and composition of landfill body (1)	yearly	
5.2. Settling behaviour of the level of the landfill Body	yearly	yearly reading

(1) Data for the status plan of the concerned landfill: surface occupied by waste, volume and composition of waste, methods of depositing, time and duration of depositing, calculation of the remaining capacity still available at the landfill.

ANNEX III. KYOTO PROTOCOL

TO THE

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

The Parties to this Protocol,

Being Parties to the United Nations Framework Convention on Climate Change, hereinafter referred to as "the Convention",

In pursuit of the ultimate objective of the Convention as stated in its Article 2,

Recalling the provisions of the Convention,

Being guided by Article 3 of the Convention,

Pursuant to the Berlin Mandate adopted by decision 1/CP.1 of the

Conference of the Parties to the Convention at its first session,

Have agreed as follows:

Article 1

For the purposes of this Protocol, the definitions contained in Article 1 of the Convention shall apply. In addition:

1. "Conference of the Parties" means the Conference of the Parties to the Convention.

2. "Convention" means the United Nations Framework Convention on Climate Change, adopted in New York on 9 May 1992.

3. "Intergovernmental Panel on Climate Change" means the Intergovernmental Panel on Climate Change established in 1988 jointly by the World Meteorological Organization and the United Nations Environment Programme.

4. "Montreal Protocol" means the Montreal Protocol on Substances that Deplete the Ozone Layer, adopted in Montreal on 16 September 1987 and as subsequently adjusted and amended.

5. "Parties present and voting" means Parties present and casting an affirmative or negative vote.

6. "Party" means, unless the context otherwise indicates, a Party to this Protocol.

7. "Party included in Annex I" means a Party included in Annex I to the Convention, as may be amended, or a Party which has made a notification under Article 4, paragraph 2(g), of the Convention.

Article 2

1. Each Party included in Annex I, in achieving its quantified emission limitation and reduction commitments under Article 3, in order to promote sustainable development, shall:

(a) Implement and/or further elaborate policies and measures in accordance with its national circumstances, such as:

(i) Enhancement of energy efficiency in relevant sectors of the national economy;

(ii) Protection and enhancement of sinks and reservoirs of greenhouse gases not controlled by the Montreal Protocol, taking into account its commitments under relevant international environmental agreements; promotion of sustainable forest management practices, afforestation and reforestation;

(iii) Promotion of sustainable forms of agriculture in light of climate change considerations;

(iv) Research on, and promotion, development and increased use of, new and renewable forms of energy, of carbon dioxide sequestration technologies and of advanced and innovative environmentally sound technologies;

(v) Progressive reduction or phasing out of market imperfections, fiscal incentives, tax and duty exemptions and subsidies in all greenhouse gas emitting sectors that run counter to the objective of the Convention and application of market instruments;

(vi) Encouragement of appropriate reforms in relevant sectors aimed at promoting policies and measures which limit or reduce emissions of greenhouse gases not controlled by the Montreal Protocol;

(vii) Measures to limit and/or reduce emissions of greenhouse gases not controlled by the Montreal Protocol in the transport sector;

(viii) Limitation and/or reduction of methane emissions through recovery and use in waste management, as well as in the production, transport and distribution of energy;

(b) Cooperate with other such Parties to enhance the individual and combined effectiveness of their policies and measures adopted under this Article, pursuant to Article 4, paragraph 2(e)(i), of the Convention. To this end, these Parties shall take steps to share their experience and exchange information on such policies and measures, including developing ways of improving their comparability, transparency and effectiveness. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, consider ways to facilitate such cooperation, taking into account all relevant information.

2. The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively.

3. The Parties included in Annex I shall strive to implement policies and measures under this Article in such a way as to minimize adverse effects, including the adverse effects of climate change, effects on international trade, and social, environmental and economic impacts on other Parties, especially developing country Parties and in particular those identified in Article 4, paragraphs 8 and 9, of the Convention, taking into account Article 3 of the Convention. The Conference of the Parties serving as the meeting of the Parties to this Protocol may take further action, as appropriate, to promote the implementation of the provisions of this paragraph.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol, if it decides that it would be beneficial to coordinate any of the policies and measures in

paragraph 1(a) above, taking into account different national circumstances and potential effects, shall consider ways and means to elaborate the coordination of such policies and measures.

Article 3

1. The Parties included in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.

2. Each Party included in Annex I shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol.

3. The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.

4. Prior to the first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol, each Party included in Annex I shall provide, for consideration by the Subsidiary Body for Scientific and Technological Advice, data to establish its level of carbon stocks in 1990 and to enable an estimate to be made of its changes in carbon stocks in subsequent years. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session or as soon as practicable thereafter, decide upon modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of the Intergovernmental Panel on Climate Change, the advice provided by the Subsidiary Body for Scientific and Technological Advice in accordance with Article 5 and the decisions of the Conference of the Parties. Such a decision shall apply in the second and subsequent commitment periods. A Party may choose to apply such a decision on these additional human-induced activities for its first commitment period, provided that these activities have taken place since 1990.

5. The Parties included in Annex I undergoing the process of transition to a market economy whose base year or period was established pursuant to decision 9/CP.2 of the Conference of the Parties at its second session shall use that base year or period for the implementation of their commitments under this Article. Any other Party included in Annex I undergoing the process of transition to a market economy which has not yet submitted its first national communication under Article 12 of the Convention may also notify the Conference of the Parties serving as the meeting of the Parties to this Protocol that it intends to use an historical base year or period other than 1990 for the implementation of its commitments under this Article. The Conference of the Parties

serving as the meeting of the Parties to this Protocol shall decide on the acceptance of such notification.

6. Taking into account Article 4, paragraph 6, of the Convention, in the implementation of their commitments under this Protocol other than those under this Article, a certain degree of flexibility shall be allowed by the Conference of the Parties serving as the meeting of the Parties to this Protocol to the Parties included in Annex I undergoing the process of transition to a market economy.

7. In the first quantified emission limitation and reduction commitment period, from 2008 to 2012, the assigned amount for each Party included in Annex I shall be equal to the percentage inscribed for it in Annex B of its aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A in 1990, or the base year or period determined in accordance with paragraph 5 above, multiplied by five. Those Parties included in Annex I for whom land-use change and forestry constituted a net source of greenhouse gas emissions in 1990 shall include in their 1990 emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in 1990 from land-use change for the purposes of calculating their assigned amount.

8. Any Party included in Annex I may use 1995 as its base year for hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, for the purposes of the calculation referred to in paragraph 7 above.

9. Commitments for subsequent periods for Parties included in Annex I shall be established in amendments to Annex B to this Protocol, which shall be adopted in accordance with the provisions of Article 21, paragraph 7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall initiate the consideration of such commitments at least seven years before the end of the first commitment period referred to in paragraph 1 above.

10. Any emission reduction units, or any part of an assigned amount, which a Party acquires from another Party in accordance with the provisions of Article 6 or of Article 17 shall be added to the assigned amount for the acquiring Party.

11. Any emission reduction units, or any part of an assigned amount, which a Party transfers to another Party in accordance with the provisions of Article 6 or of Article 17 shall be subtracted from the assigned amount for the transferring Party.

12. Any certified emission reductions which a Party acquires from another Party in accordance with the provisions of Article 12 shall be added to the assigned amount for the acquiring Party.

13. If the emissions of a Party included in Annex I in a commitment period are less than its assigned amount under this Article, this difference shall, on request of that Party, be added to the assigned amount for that Party for subsequent commitment periods.

14. Each Party included in Annex I shall strive to implement the commitments mentioned in paragraph 1 above in such a way as to minimize adverse social, environmental and economic impacts on developing country Parties, particularly those identified in Article 4, paragraphs 8 and 9, of the Convention. In line with relevant decisions of the Conference of the Parties on the implementation of those paragraphs, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at

its first session, consider what actions are necessary to minimize the adverse effects of climate change and/or the impacts of response measures on Parties referred to in those paragraphs. Among the issues to be considered shall be the establishment of funding, insurance and transfer of technology.

Article 4

1. Any Parties included in Annex I that have reached an agreement to fulfil their commitments under Article 3 jointly, shall be deemed to have met those commitments provided that their total combined aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of Article 3. The respective emission level allocated to each of the Parties to the agreement shall be set out in that agreement.

2. The Parties to any such agreement shall notify the secretariat of the terms of the agreement on the date of deposit of their instruments of ratification, acceptance or approval of this Protocol, or accession thereto. The secretariat shall in turn inform the Parties and signatories to the Convention of the terms of the agreement.

3. Any such agreement shall remain in operation for the duration of the commitment period specified in Article 3, paragraph 7.

4. If Parties acting jointly do so in the framework of, and together with, a regional economic integration organization, any alteration in the composition of the organization after adoption of this Protocol shall not affect existing commitments under this Protocol. Any alteration in the composition of the organization shall only apply for the purposes of those commitments under Article 3 that are adopted subsequent to that alteration.

5. In the event of failure by the Parties to such an agreement to achieve their total combined level of emission reductions, each Party to that agreement shall be responsible for its own level of emissions set out in the agreement.

6. If Parties acting jointly do so in the framework of, and together with, a regional economic integration organization which is itself a Party to this Protocol, each member State of that regional economic integration organization individually, and together with the regional economic integration organization acting in accordance with Article 24, shall, in the event of failure to achieve the total combined level of emission reductions, be responsible for its level of emissions as notified in accordance with this Article.

Article 5

1. Each Party included in Annex I shall have in place, no later than one year prior to the start of the first commitment period, a national system for the estimation of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. Guidelines for such national systems, which shall incorporate the methodologies specified in paragraph 2 below, shall be decided upon by the Conference of the Parties serving as the meeting of the Parties to this Protocol at its first session.

2. Methodologies for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol shall be those

accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties at its third session. Where such methodologies are not used, appropriate adjustments shall be applied according to methodologies agreed upon by the Conference of the Parties serving as the meeting of the Parties to this Protocol at its first session. Based on the work of, *inter alia*, the Intergovernmental Panel on Climate Change and advice provided by the Subsidiary Body for Scientific and Technological Advice, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall regularly review and, as appropriate, revise such methodologies and adjustments, taking fully into account any relevant decisions by the Conference of the Parties. Any revision to methodologies or adjustments shall be used only for the purposes of ascertaining compliance with commitments under Article 3 in respect of any commitment period adopted subsequent to that revision.

3. The global warming potentials used to calculate the carbon dioxide equivalence of anthropogenic emissions by sources and removals by sinks of greenhouse gases listed in Annex A shall be those accepted by the Intergovernmental Panel on Climate Change and agreed upon by the Conference of the Parties at its third session. Based on the work of, *inter alia*, the Intergovernmental Panel on Climate Change and advice provided by the Subsidiary Body for Scientific and Technological Advice, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall regularly review and, as appropriate, revise the global warming potential of each such greenhouse gas, taking fully into account any relevant decisions by the Conference of the Parties. Any revision to a global warming potential shall apply only to commitments under Article 3 in respect of any commitment period adopted subsequent to that revision.

Article 6

1. For the purpose of meeting its commitments under Article 3, any Party included in Annex I may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy, provided that:

(a) Any such project has the approval of the Parties involved;

(b) Any such project provides a reduction in emissions by sources, or an enhancement of removals by sinks, that is additional to any that would otherwise occur;

(c) It does not acquire any emission reduction units if it is not in compliance with its obligations under Articles 5 and 7; and

(d) The acquisition of emission reduction units shall be supplemental to domestic actions for the purposes of meeting commitments under Article 3.

2. The Conference of the Parties serving as the meeting of the Parties to this Protocol may, at its first session or as soon as practicable thereafter, further elaborate guidelines for the implementation of this Article, including for verification and reporting.

3. A Party included in Annex I may authorize legal entities to participate, under its responsibility, in actions leading to the generation, transfer or acquisition under this Article of emission reduction units.

4. If a question of implementation by a Party included in Annex I of the requirements referred to in this Article is identified in accordance with the relevant provisions of Article 8, transfers and acquisitions of emission reduction units may continue to be made after the question has been identified, provided that any such units may not be used by a Party to meet its commitments under Article 3 until any issue of compliance is resolved.

Article 7

1. Each Party included in Annex I shall incorporate in its annual inventory of anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol, submitted in accordance with the relevant decisions of the Conference of the Parties, the necessary supplementary information for the purposes of ensuring compliance with Article 3, to be determined in accordance with paragraph 4 below.

2. Each Party included in Annex I shall incorporate in its national communication, submitted under Article 12 of the Convention, the supplementary information necessary to demonstrate compliance with its commitments under this Protocol, to be determined in accordance with paragraph 4 below.

3. Each Party included in Annex I shall submit the information required under paragraph 1 above annually, beginning with the first inventory due under the Convention for the first year of the commitment period after this Protocol has entered into force for that Party. Each such Party shall submit the information required under paragraph 2 above as part of the first national communication due under the Convention after this Protocol has entered into force for it and after the adoption of guidelines as provided for in paragraph 4 below. The frequency of subsequent submission of information required under this Article shall be determined by the Conference of the Parties serving as the meeting of the Parties to this Protocol, taking into account any timetable for the submission of national communications decided upon by the Conference of the Parties.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall adopt at its first session, and review periodically thereafter, guidelines for the preparation of the information required under this Article, taking into account guidelines for the preparation of national communications by Parties included in Annex I adopted by the Conference of the Parties. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall also, prior to the first commitment period, decide upon modalities for the accounting of assigned amounts.

Article 8

1. The information submitted under Article 7 by each Party included in Annex I shall be reviewed by expert review teams pursuant to the relevant decisions of the Conference of the Parties and in accordance with guidelines adopted for this purpose by the Conference of the Parties serving as the meeting of the Parties to this Protocol under paragraph 4 below. The information submitted under Article 7, paragraph 1, by each Party included in Annex I shall be reviewed as part of the annual compilation and accounting of emissions inventories and assigned amounts. Additionally, the information submitted under Article 7, paragraph 2, by each Party included in Annex I shall be reviewed as part of the review of communications.

2. Expert review teams shall be coordinated by the secretariat and shall be composed of experts selected from those nominated by Parties to the Convention and, as appropriate,

by intergovernmental organizations, in accordance with guidance provided for this purpose by the Conference of the Parties.

3. The review process shall provide a thorough and comprehensive technical assessment of all aspects of the implementation by a Party of this Protocol. The expert review teams shall prepare a report to the Conference of the Parties serving as the meeting of the Parties to this Protocol**,** assessing the implementation of the commitments of the Party and identifying any potential problems in, and factors influencing, the fulfilment of commitments. Such reports shall be circulated by the secretariat to all Parties to the Convention. The secretariat shall list those questions of implementation indicated in such reports for further consideration by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall adopt at its first session, and review periodically thereafter, guidelines for the review of implementation of this Protocol by expert review teams taking into account the relevant decisions of the Conference of the Parties.

5. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, with the assistance of the Subsidiary Body for Implementation and, as appropriate, the Subsidiary Body for Scientific and Technological Advice, consider:

(a) The information submitted by Parties under Article 7 and the reports of the expert reviews thereon conducted under this Article; and

(b) Those questions of implementation listed by the secretariat under paragraph 3 above, as well as any questions raised by Parties.

6. Pursuant to its consideration of the information referred to in paragraph 5 above, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall take decisions on any matter required for the implementation of this Protocol.

Article 9

1. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall periodically review this Protocol in the light of the best available scientific information and assessments on climate change and its impacts, as well as relevant technical, social and economic information. Such reviews shall be coordinated with pertinent reviews under the Convention, in particular those required by Article 4, paragraph 2(d), and Article 7, paragraph 2(a), of the Convention. Based on these reviews, the Conference of the Parties serving as the meeting of the Parties to this Protocol shall take appropriate action.

2. The first review shall take place at the second session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. Further reviews shall take place at regular intervals and in a timely manner.

Article 10

All Parties, taking into account their common but differentiated responsibilities and their specific national and regional development priorities, objectives and circumstances, without introducing any new commitments for Parties not included in Annex I, but reaffirming existing commitments under Article 4, paragraph 1, of the Convention, and continuing to advance the implementation of these commitments in order to achieve

sustainable development, taking into account Article 4, paragraphs 3, 5 and 7, of the Convention, shall:

(a) Formulate, where relevant and to the extent possible, cost-effective national and, where appropriate, regional programmes to improve the quality of local emission factors, activity data and/or models which reflect the socio-economic conditions of each Party for the preparation and periodic updating of national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties, and consistent with the guidelines for the preparation of national communications adopted by the Conference of the Parties;

(b) Formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change:

(i) Such programmes would, *inter alia*, concern the energy, transport and industry sectors as well as agriculture, forestry and waste management. Furthermore, adaptation technologies and methods for improving spatial planning would improve adaptation to climate change; and

(ii) Parties included in Annex I shall submit information on action under this Protocol, including national programmes, in accordance with Article 7; and other Parties shall seek to include in their national communications, as appropriate, information on programmes which contain measures that the Party believes contribute to addressing climate change and its adverse impacts, including the abatement of increases in greenhouse gas emissions, and enhancement of and removals by sinks, capacity building and adaptation measures;

(c) Cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies;

(d) Cooperate in scientific and technical research and promote the maintenance and the development of systematic observation systems and development of data archives to reduce uncertainties related to the climate system, the adverse impacts of climate change and the economic and social consequences of various response strategies, and promote the development and strengthening of endogenous capacities and capabilities to participate in international and intergovernmental efforts, programmes and networks on research and systematic observation, taking into account Article 5 of the Convention;

(e) Cooperate in and promote at the international level, and, where appropriate, using existing bodies, the development and implementation of education and training programmes, including the strengthening of national capacity building, in particular human and institutional capacities and the exchange or secondment of personnel to train experts in this field, in particular for developing countries, and facilitate at the national level public awareness of, and public access to information on, climate change. Suitable

modalities should be developed to implement these activities through the relevant bodies of the Convention, taking into account Article 6 of the Convention;

(f) Include in their national communications information on programmes and activities undertaken pursuant to this Article in accordance with relevant decisions of the Conference of the Parties; and

(g) Give full consideration, in implementing the commitments under this Article, to Article 4, paragraph 8, of the Convention.

Article 11

1. In the implementation of Article 10, Parties shall take into account the provisions of Article 4, paragraphs 4, 5, 7, 8 and 9, of the Convention.

2. In the context of the implementation of Article 4, paragraph 1, of the Convention, in accordance with the provisions of Article 4, paragraph 3, and Article 11 of the Convention, and through the entity or entities entrusted with the operation of the financial mechanism of the Convention, the developed country Parties and other developed Parties included in Annex II to the Convention shall:

(a) Provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in advancing the implementation of existing commitments under Article 4, paragraph 1(a), of the Convention that are covered in Article 10, subparagraph (a); and

(b) Also provide such financial resources, including for the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of advancing the implementation of existing commitments under Article 4, paragraph 1, of the Convention that are covered by Article 10 and that are agreed between a developing country Party and the international entity or entities referred to in Article 11 of the Convention, in accordance with that Article.

The implementation of these existing commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among developed country Parties. The guidance to the entity or entities entrusted with the operation of the financial mechanism of the Convention in relevant decisions of the Conference of the Parties, including those agreed before the adoption of this Protocol, shall apply *mutatis mutandis* to the provisions of this paragraph.

3. The developed country Parties and other developed Parties in Annex II to the Convention may also provide, and developing country Parties avail themselves of, financial resources for the implementation of Article 10, through bilateral, regional and other multilateral channels.

Article 12

1. A clean development mechanism is hereby defined.

2. The purpose of the clean development mechanism shall be to assist Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.

3. Under the clean development mechanism:

(a) Parties not included in Annex I will benefit from project activities resulting in certified emission reductions; and

(b) Parties included in Annex I may use the certified emission reductions accruing from such project activities to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3, as determined by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

4. The clean development mechanism shall be subject to the authority and guidance of the Conference of the Parties serving as the meeting of the Parties to this Protocol and be supervised by an executive board of the clean development mechanism.

5. Emission reductions resulting from each project activity shall be certified by operational entities to be designated by the Conference of the Parties serving as the meeting of the Parties to this Protocol, on the basis of:

(a) Voluntary participation approved by each Party involved;

(b) Real, measurable, and long-term benefits related to the mitigation of climate change; and

(c) Reductions in emissions that are additional to any that would occur in the absence of the certified project activity.

6. The clean development mechanism shall assist in arranging funding of certified project activities as necessary.

7. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, elaborate modalities and procedures with the objective of ensuring transparency, efficiency and accountability through independent auditing and verification of project activities.

8. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall ensure that a share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation.

9. Participation under the clean development mechanism, including in activities mentioned in paragraph 3(a) above and in the acquisition of certified emission reductions, may involve private and/or public entities, and is to be subject to whatever guidance may be provided by the executive board of the clean development mechanism.

10. Certified emission reductions obtained during the period from the year 2000 up to the beginning of the first commitment period can be used to assist in achieving compliance in the first commitment period.

Article 13

1. The Conference of the Parties, the supreme body of the Convention, shall serve as the meeting of the Parties to this Protocol.

2. Parties to the Convention that are not Parties to this Protocol may participate as observers in the proceedings of any session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the Conference of the Parties serves as the meeting of the Parties to this Protocol, any member of the Bureau of the Conference of the Parties representing a Party to the Convention but, at that time, not a Party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

4. The Conference of the Parties serving as the meeting of the Parties to this Protocol shall keep under regular review the implementation of this Protocol and shall make, within its mandate, the decisions necessary to promote its effective implementation. It shall perform the functions assigned to it by this Protocol and shall:

(a) Assess, on the basis of all information made available to it in accordance with the provisions of this Protocol, the implementation of this Protocol by the Parties, the overall effects of the measures taken pursuant to this Protocol, in particular environmental, economic and social effects as well as their cumulative impacts and the extent to which progress towards the objective of the Convention is being achieved;

(b) Periodically examine the obligations of the Parties under this Protocol, giving due consideration to any reviews required by Article 4, paragraph 2(d), and Article 7, paragraph 2, of the Convention, in the light of the objective of the Convention, the experience gained in its implementation and the evolution of scientific and technological knowledge, and in this respect consider and adopt regular reports on the implementation of this Protocol;

(c) Promote and facilitate the exchange of information on measures adopted by the Parties to address climate change and its effects, taking into account the differing circumstances, responsibilities and capabilities of the Parties and their respective commitments under this Protocol;

(d) Facilitate, at the request of two or more Parties, the coordination of measures adopted by them to address climate change and its effects, taking into account the differing circumstances, responsibilities and capabilities of the Parties and their respective commitments under this Protocol;

(e) Promote and guide, in accordance with the objective of the Convention and the provisions of this Protocol, and taking fully into account the relevant decisions by the Conference of the Parties, the development and periodic refinement of comparable methodologies for the effective implementation of this Protocol, to be agreed on by the Conference of the Parties serving as the meeting of the Parties to this Protocol;

(f) Make recommendations on any matters necessary for the implementation of this Protocol;

(g) Seek to mobilize additional financial resources in accordance with

Article 11, paragraph 2;

(h) Establish such subsidiary bodies as are deemed necessary for the implementation of this Protocol;

(i) Seek and utilize, where appropriate, the services and cooperation of, and information provided by, competent international organizations and intergovernmental and non-governmental bodies; and

(j) Exercise such other functions as may be required for the implementation of this Protocol, and consider any assignment resulting from a decision by the Conference of the Parties.

5. The rules of procedure of the Conference of the Parties and financial procedures applied under the Convention shall be applied *mutatis mutandis* under this Protocol, except as may be otherwise decided by consensus by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

6. The first session of the Conference of the Parties serving as the meeting of the Parties to this Protocol shall be convened by the secretariat in conjunction with the first session of the Conference of the Parties that is scheduled after the date of the entry into force of this Protocol. Subsequent ordinary sessions of the Conference of the Parties serving as the meeting of the Parties to this Protocol shall be held every year and in conjunction with ordinary sessions of the Conference of the Parties, unless otherwise decided by the Conference of the Parties serving as the meeting of the Parties to this Protocol.

7. Extraordinary sessions of the Conference of the Parties serving as the meeting of the Parties to this Protocol shall be held at such other times as may be deemed necessary by the Conference of the Parties serving as the meeting of the Parties to this Protocol, or at the written request of any Party, provided that, within six months of the request being communicated to the Parties by the secretariat, it is supported by at least one third of the Parties.

8. The United Nations, its specialized agencies and the International Atomic Energy

Agency, as well as any State member thereof or observers thereto not party to the Convention, may be represented at sessions of the Conference of the Parties serving as the meeting of the Parties to this Protocol as observers. Any body or agency, whether national or international, governmental or non-governmental, which is qualified in matters covered by this Protocol and which has informed the secretariat of its wish to be represented at a session of the Conference of the Parties serving as the meeting of the Parties to this Protocol as an observer, may be so admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure, as referred to in paragraph 5 above.

Article 14

1. The secretariat established by Article 8 of the Convention shall serve as the secretariat of this Protocol.

2. Article 8, paragraph 2, of the Convention on the functions of the secretariat, and

Article 8, paragraph 3, of the Convention on arrangements made for the functioning of the secretariat, shall apply *mutatis mutandis* to this Protocol. The secretariat shall, in addition, exercise the functions assigned to it under this Protocol.

Article 15

1. The Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation established by Articles 9 and 10 of the Convention shall serve as, respectively, the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of this Protocol. The provisions relating to the functioning of these two bodies under the Convention shall apply *mutatis mutandis* to this Protocol. Sessions of the meetings of the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of this Protocol shall be held in conjunction with the meetings of, respectively, the Subsidiary Body for Scientific and Technological Advice and the Subsidiary Body for Implementation of the Convention.

2. Parties to the Convention that are not Parties to this Protocol may participate as observers in the proceedings of any session of the subsidiary bodies. When the subsidiary bodies serve as the subsidiary bodies of this Protocol, decisions under this Protocol shall be taken only by those that are Parties to this Protocol.

3. When the subsidiary bodies established by Articles 9 and 10 of the Convention exercise their functions with regard to matters concerning this Protocol, any member of the Bureaux of those subsidiary bodies representing a Party to the Convention but, at that time, not a party to this Protocol, shall be replaced by an additional member to be elected by and from amongst the Parties to this Protocol.

Article 16

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, as soon as practicable, consider the application to this Protocol of, and modify as appropriate, the multilateral consultative process referred to in Article 13 of the Convention, in the light of any relevant decisions that may be taken by the Conference of the Parties. Any multilateral consultative process that may be applied to this Protocol shall operate without prejudice to the procedures and mechanisms established in accordance with Article 18.

Article 17

The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading. The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.

Article 18

The Conference of the Parties serving as the meeting of the Parties to this Protocol shall, at its first session, approve appropriate and effective procedures and mechanisms to determine and to address cases of non-compliance with the provisions of this Protocol, including through the development of an indicative list of consequences, taking into account the cause, type, degree and frequency of non-compliance. Any procedures and

mechanisms under this Article entailing binding consequences shall be adopted by means of an amendment to this Protocol.

Article 19

The provisions of Article 14 of the Convention on settlement of disputes shall apply *mutatis mutandis* to this Protocol.

Article 20

1. Any Party may propose amendments to this Protocol.

2. Amendments to this Protocol shall be adopted at an ordinary session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. The text of any proposed amendment to this Protocol shall be communicated to the Parties by the secretariat at least six months before the meeting at which it is proposed for adoption. The secretariat shall also communicate the text of any proposed amendments to the Parties and signatories to the Convention and, for information, to the Depositary.

3. The Parties shall make every effort to reach agreement on any proposed amendment to this Protocol by consensus. If all efforts at consensus have been exhausted, and no agreement reached, the amendment shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting. The adopted amendment shall be communicated by the secretariat to the Depositary, who shall circulate it to all Parties for their acceptance.

4. Instruments of acceptance in respect of an amendment shall be deposited with the Depositary. An amendment adopted in accordance with paragraph 3 above shall enter into force for those Parties having accepted it on the ninetieth day after the date of receipt by the Depositary of an instrument of acceptance by at least three fourths of the Parties to this Protocol.

5. The amendment shall enter into force for any other Party on the ninetieth day after the date on which that Party deposits with the Depositary its instrument of acceptance of the said amendment.

Article 21

1. Annexes to this Protocol shall form an integral part thereof and, unless otherwise expressly provided, a reference to this Protocol constitutes at the same time a reference to any annexes thereto. Any annexes adopted after the entry into force of this Protocol shall be restricted to lists, forms and any other material of a descriptive nature that is of a scientific, technical, procedural or administrative character.

2. Any Party may make proposals for an annex to this Protocol and may propose amendments to annexes to this Protocol.

3. Annexes to this Protocol and amendments to annexes to this Protocol shall be adopted at an ordinary session of the Conference of the Parties serving as the meeting of the Parties to this Protocol. The text of any proposed annex or amendment to an annex shall be communicated to the Parties by the secretariat at least six months before the meeting at which it is proposed for adoption. The secretariat shall also communicate the text of any proposed annex or amendment to an annex to the Parties and signatories to the Convention and, for information, to the Depositary.

4. The Parties shall make every effort to reach agreement on any proposed annex or amendment to an annex by consensus. If all efforts at consensus have been exhausted, and no agreement reached, the annex or amendment to an annex shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting. The adopted annex or amendment to an annex shall be communicated by the secretariat to the Depositary, who shall circulate it to all Parties for their acceptance.

5. An annex, or amendment to an annex other than Annex A or B, that has been adopted in accordance with paragraphs 3 and 4 above shall enter into force for all Parties to this Protocol six months after the date of the communication by the Depositary to such Parties of the adoption of the annex or adoption of the amendment to the annex, except for those Parties that have notified the Depositary, in writing, within that period of their non-acceptance of the annex or amendment to the annex. The annex or amendment to an annex shall enter into force for Parties which withdraw their notification of non-acceptance on the ninetieth day after the date on which withdrawal of such notification has been received by the Depositary.

6. If the adoption of an annex or an amendment to an annex involves an amendment to this Protocol, that annex or amendment to an annex shall not enter into force until such time as the amendment to this Protocol enters into force.

7. Amendments to Annexes A and B to this Protocol shall be adopted and enter into force in accordance with the procedure set out in Article 20, provided that any amendment to Annex B shall be adopted only with the written consent of the Party concerned**.**

Article 22

1. Each Party shall have one vote, except as provided for in paragraph 2 below.

2. Regional economic integration organizations, in matters within their competence, shall exercise their right to vote with a number of votes equal to the number of their member States that are Parties to this Protocol. Such an organization shall not exercise its right to vote if any of its member States exercises its right, and vice versa.

Article 23

The Secretary-General of the United Nations shall be the Depositary of this Protocol.

Article 24

1. This Protocol shall be open for signature and subject to ratification, acceptance or approval by States and regional economic integration organizations which are Parties to the Convention. It shall be open for signature at United Nations Headquarters in New York from

16 March 1998 to 15 March 1999. This Protocol shall be open for accession from the day after the date on which it is closed for signature. Instruments of ratification, acceptance, approval or accession shall be deposited with the Depositary.

2. Any regional economic integration organization which becomes a Party to this Protocol without any of its member States being a Party shall be bound by all the obligations under this Protocol. In the case of such organizations, one or more of whose member States is a Party to this Protocol, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under

this Protocol. In such cases, the organization and the member States shall not be entitled to exercise rights under this Protocol concurrently.

3. In their instruments of ratification, acceptance, approval or accession, regional economic integration organizations shall declare the extent of their competence with respect to the matters governed by this Protocol. These organizations shall also inform the Depositary, who shall in turn inform the Parties, of any substantial modification in the extent of their competence.

Article 25

1. This Protocol shall enter into force on the ninetieth day after the date on which not less than 55 Parties to the Convention, incorporating Parties included in Annex I which accounted in total for at least 55 per cent of the total carbon dioxide emissions for 1990 of the Parties included in Annex I, have deposited their instruments of ratification, acceptance, approval or accession.

2. For the purposes of this Article, "the total carbon dioxide emissions for 1990 of the Parties included in Annex I" means the amount communicated on or before the date of adoption of this Protocol by the Parties included in Annex I in their first national communications submitted in accordance with Article 12 of the Convention.

3. For each State or regional economic integration organization that ratifies, accepts or

approves this Protocol or accedes thereto after the conditions set out in paragraph 1 above for entry into force have been fulfilled, this Protocol shall enter into force on the ninetieth day following the date of deposit of its instrument of ratification, acceptance, approval or accession.

4. For the purposes of this Article, any instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by States members of the organization.

Article 26

No reservations may be made to this Protocol.

Article 27

1. At any time after three years from the date on which this Protocol has entered into force for a Party, that Party may withdraw from this Protocol by giving written notification to the Depositary.

2. Any such withdrawal shall take effect upon expiry of one year from the date of receipt by the Depositary of the notification of withdrawal, or on such later date as may be specified in the notification of withdrawal.

3. Any Party that withdraws from the Convention shall be considered as also having withdrawn from this Protocol.

Article 28

The original of this Protocol, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

DONE at Kyoto this eleventh day of December one thousand nine hundred and ninety-seven.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have affixed their signatures to this Protocol on the dates indicated.

Annex A

Greenhouse gases

Carbon dioxide (CO_2)

Methane (CH_4)

Nitrous oxide (N_2O)

Hydrofluorocarbons (HFCs)

Perfluorocarbons (PFCs)

Sulphur hexafluoride (SF_6)

Sectors/source categories

Energy

Fuel combustion

Energy industries

Manufacturing industries and construction

Transport

Other sectors

Other

Fugitive emissions from fuels

Solid fuels

Oil and natural gas

Other

Industrial processes

Mineral products

Chemical industry

Metal production

Other production

Production of halocarbons and sulphur hexafluoride

Consumption of halocarbons and sulphur hexafluoride

Other

Solvent and other product use

Agriculture

Enteric fermentation

Manure management

Rice cultivation

Agricultural soils

Prescribed burning of savannas

Field burning of agricultural residues

Other

Waste

Solid waste disposal on land

Wastewater handling

Waste incineration

Other

Annex B

Party	**Quantified emission limitation or reduction commitment** (percentage of base year or period)
Australia	108
Austria	92
Belgium	92
Bulgaria*	92
Canada	94
Croatia*	95
Czech Republic*	92
Denmark	92
Estonia*	92
European Community	92
Finland	92
France	92
Germany	92
Greece	92
Hungary*	94
Iceland	110
Ireland	92
Italy	92
Japan	94
Latvia*	92
Liechtenstein	92
Lithuania*	92
Luxembourg	92
Monaco	92

Netherlands 92

New Zealand 100

Norway 101

Poland* 94

Portugal 92

Romania* 92

Russian Federation* 100

Slovakia* 92

Slovenia* 92

Spain 92

Sweden 92

Switzerland 92

Ukraine* 100

United Kingdom of Great Britain and Northern Ireland 92

United States of America 93

* Countries that are undergoing the process of transition to a market economy.

- - - - -

ANNEX IV. MONTREAL PROTOCOL

The Montreal Protocol on Substances that Deplete the Ozone Layer

as adjusted and/or amended in

London 1990
Copenhagen 1992
Vienna 1995
Montreal 1997
Beijing 1999

UNEP

Ozone Secretariat
United Nations Environment Programme

Published 2000

by
Secretariat for
The Vienna Convention for the Protection of the Ozone Layer &
The Montreal Protocol on Substances that Deplete the Ozone Layer

United Nations Environment Programme
PO Box 30552
Nairobi
Kenya
web site: http://www.unep.org/ozone

ISBN: 92-807-1888-6

Printed and bound in Kenya by UNON. Printed on recycled paper.

Cover design by UNON Printshop (March 2000)

Co-ordination: K. Madhava Sarma, Executive Secretary, Ozone Secretariat, UNEP
Gilbert M. Bankobeza, Senior Legal Officer, Ozone Secretariat, UNEP

Layout and Formatting: Martha A. Mulumba, Ozone Secretariat, UNEP

Table of Contents

Preamble

Article 1: Definitions

Article 2: Control Measures

Article 2A: CFCs

Article 2B: Halons

Article 2C: Other fully halogenated CFCs

Article 2D: Carbon tetrachloride

Article 2E: 1,1,1-Trichloroethane (Methyl chloroform)

Article 2F: Hydrochlorofluorocarbons

Article 2G: Hydrobromofluorocarbons

Article 2H: Methyl bromide

Article 2I: Bromochloromethane

Article 3: Calculation of control levels

Article 4: Control of trade with non-Parties

Article 4A: Control of trade with Parties

Article 4B: Licensing

Article 5: Special situation of developing countries

Article 6: Assessment and review of control measures

Article 7: Reporting of data

Article 8: Non-compliance

Article 9: Research, development, public awareness and exchange of information

Article 10: Financial mechanism

Article 10A: Transfer of technology

Article 11: Meetings of the parties

Article 12: Secretariat

Article 13: Financial provisions

Article 14: Relationship of this Protocol to the Convention

Article 15: Signature

Article 16: Entry into force

Article 17: Parties joining after entry into force

Article 18: Reservations

Article 19: Withdrawal

Article 20: Authentic texts

Annex A: Controlled substances

Annex B: Controlled substances

Annex C: Controlled substances

Annex D:* A list of products** containing controlled substances specified in Annex A

Annex E: Controlled substance

Preamble

The Parties to this Protocol,

Being Parties to the Vienna Convention for the Protection of the Ozone Layer,

Mindful of their obligation under that Convention to take appropriate measures to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer,

Recognizing that world-wide emissions of certain substances can significantly deplete and otherwise modify the ozone layer in a manner that is likely to result in adverse effects on human health and the environment,

Conscious of the potential climatic effects of emissions of these substances,

Aware that measures taken to protect the ozone layer from depletion should be based on relevant scientific knowledge, taking into account technical and economic considerations,

Determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge, taking into account technical and economic considerations and bearing in mind the developmental needs of developing countries,

Acknowledging that special provision is required to meet the needs of developing countries, including the provision of additional financial resources and access to relevant technologies, bearing in mind that the magnitude of funds necessary is predictable, and the funds can be expected to make a substantial difference in the world's ability to address the scientifically established problem of ozone depletion and its harmful effects,

Noting the precautionary measures for controlling emissions of certain chlorofluorocarbons that have already been taken at national and regional levels,

Considering the importance of promoting international co-operation in the research, development and transfer of alternative technologies relating to the control and reduction of emissions of substances that deplete the ozone layer, bearing in mind in particular the needs of developing countries,

HAVE AGREED AS FOLLOWS:

Article 1: Definitions

For the purposes of this Protocol:

1. "Convention" means the Vienna Convention for the Protection of the Ozone Layer, adopted on 22 March 1985.

2. "Parties" means, unless the text otherwise indicates, Parties to this Protocol.

3. "Secretariat" means the Secretariat of the Convention.

4. "Controlled substance" means a substance in Annex A, Annex B, Annex C or Annex E to this Protocol, whether existing alone or in a mixture. It includes the isomers of any such substance, except as specified in the relevant Annex, but excludes any controlled substance or mixture which is in a manufactured product other than a container used for the transportation or storage of that substance.

5. "Production" means the amount of controlled substances produced, minus the amount destroyed by technologies to be approved by the Parties and minus the amount entirely used as feedstock in the manufacture of other chemicals. The amount recycled and reused is not to be considered as "production".

6. "Consumption" means production plus imports minus exports of controlled substances.

7. "Calculated levels" of production, imports, exports and consumption means levels determined in accordance with Article 3.

8. "Industrial rationalization" means the transfer of all or a portion of the calculated level of production of one Party to another, for the purpose of achieving economic efficiencies or responding to anticipated shortfalls in supply as a result of plant closures.

Article 2: Control Measures

1. Incorporated in Article 2A.

2. Replaced by Article 2B.

3. Replaced by Article 2A.

4. Replaced by Article 2A.

5. Any Party may, for one or more control periods, transfer to another Party any portion of its calculated level of production set out in Articles 2A to 2F, and Article 2H, provided that the total combined calculated levels of production of the Parties concerned for any group of controlled substances do not exceed the production limits set out in those Articles for that group. Such transfer of production shall be notified to the Secretariat by each of the Parties concerned, stating the terms of such transfer and the period for which it is to apply.

5 *bis*. Any Party not operating under paragraph 1 of Article 5 may, for one or more control periods, transfer to another such Party any portion of its calculated level of consumption set out in Article 2F, provided that the calculated level of consumption of controlled substances in Group I of Annex A of the Party transferring the portion of its calculated level of consumption did not exceed 0.25 kilograms per capita in 1989 and that the total combined calculated levels of consumption of the Parties concerned do not exceed the consumption limits set out in Article 2F. Such transfer of consumption shall be notified to the Secretariat by each of the Parties concerned, stating the terms of such transfer and the period for which it is to apply.

6. Any Party not operating under Article 5, that has facilities for the production of Annex A or Annex B controlled substances under construction, or contracted for, prior to 16 September 1987, and provided for in national legislation prior to 1 January 1987, may add the production from such facilities to its 1986 production of such substances for the purposes of determining its calculated level of production for 1986, provided that such facilities are completed by 31 December 1990 and that such production does not raise that Party’s annual calculated level of consumption of the controlled substances above 0.5 kilograms per capita.

7. Any transfer of production pursuant to paragraph 5 or any addition of production pursuant to paragraph 6 shall be notified to the Secretariat, no later than the time of the transfer or addition.

8. (a) Any Parties which are Member States of a regional economic integration organization as defined in Article 1 (6) of the Convention may agree that they shall jointly fulfil their obligations respecting consumption under this Article and Articles 2A to 2I provided that their total combined calculated level of consumption does not exceed the levels required by this Article and Articles 2A to 2I.

(b) The Parties to any such agreement shall inform the Secretariat of the terms of the agreement before the date of the reduction in consumption with which the agreement is concerned.

(c) Such agreement will become operative only if all Member States of the regional economic integration organization and the organization concerned are Parties to the Protocol and have notified the Secretariat of their manner of implementation.

9. (a) Based on the assessments made pursuant to Article 6, the Parties may decide whether:

(i) Adjustments to the ozone depleting potentials specified in Annex A, Annex B, Annex C and/or Annex E should be made and, if so, what the adjustments should be; and

(ii) Further adjustments and reductions of production or consumption of the controlled substances should be undertaken and, if so, what the scope, amount and timing of any such adjustments and reductions should be;

(b) Proposals for such adjustments shall be communicated to the Parties by the Secretariat at least six months before the meeting of the Parties at which they are proposed for adoption;

(c) In taking such decisions, the Parties shall make every effort to reach agreement by consensus. If all efforts at consensus have been exhausted, and no agreement reached, such decisions shall, as a last resort, be adopted by a two-thirds majority vote of the Parties present and voting representing a majority of the Parties operating under Paragraph 1 of Article 5 present and voting and a majority of the Parties not so operating present and voting;

(d) The decisions, which shall be binding on all Parties, shall forthwith be communicated to the Parties by the Depositary. Unless otherwise provided in the decisions, they shall enter into force on the expiry of six months from the date of the circulation of the communication by the Depositary.

10. Based on the assessments made pursuant to Article 6 of this Protocol and in accordance with the procedure set out in Article 9 of the Convention, the Parties may decide:

a. whether any substances, and if so which, should be added to or removed from any annex to this Protocol, and

b. the mechanism, scope and timing of the control measures that should apply to those substances;

11. Notwithstanding the provisions contained in this Article and Articles 2A to 2I Parties may take more stringent measures than those required by this Article and Articles 2A to 2I.

Article 2A: CFCs

1. Each Party shall ensure that for the twelve-month period commencing on the first day of the seventh month following the date of entry into force of this Protocol, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex A does not exceed its calculated level of consumption in 1986. By the end of the same period, each Party producing one or more of these substances shall ensure that its calculated level of production of the substances does not exceed its calculated level of production in 1986, except that such level may have increased by no more than ten per cent based on the 1986 level. Such increase shall be permitted only so as to satisfy the basic domestic needs of the Parties operating under Article 5 and for the purposes of industrial rationalization between Parties.

2. Each Party shall ensure that for the period from 1 July 1991 to 31 December 1992 its calculated levels of consumption and production of the controlled substances in Group I of Annex A do not exceed 150 per

cent of its calculated levels of production and consumption of those substances in 1986; with effect from 1 January 1993, the twelve-month control period for these controlled substances shall run from 1 January to 31 December each year.

3. Each Party shall ensure that for the twelve-month period commencing on 1 January 1994, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex A does not exceed, annually, twenty-five per cent of its calculated level of consumption in 1986. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed, annually, twenty-five per cent of its calculated level of production in 1986. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1986.

4. Each Party shall ensure that for the twelve-month period commencing on 1 January 1996, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex A does not exceed zero. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed zero. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by a quantity equal to the annual average of its production of the controlled substances in Group I of Annex A for basic domestic needs for the period 1995 to 1997 inclusive. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.

5. Each Party shall ensure that for the twelve-month period commencing on 1 January 2003 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group I of Annex A for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed eighty per cent of the annual average of its production of those substances for basic domestic needs for the period 1995 to 1997 inclusive.

6. Each Party shall ensure that for the twelve-month period commencing on 1 January 2005 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group I of Annex A for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed fifty per cent of the annual average of its production of those substances for basic domestic needs for the period 1995 to 1997 inclusive.

7. Each Party shall ensure that for the twelve-month period commencing on 1 January 2007 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group I of Annex A for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed fifteen per cent of the annual average of its production of those substances for basic domestic needs for the period 1995 to 1997 inclusive.

8. Each Party shall ensure that for the twelve-month period commencing on 1 January 2010 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group I of Annex A for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed zero.

9. For the purposes of calculating basic domestic needs under paragraphs 4 to 8 of this Article, the calculation of the annual average of production by a Party includes any production entitlements that it has transferred in accordance with paragraph 5 of Article 2, and excludes any production entitlements that it has acquired in accordance with paragraph 5 of Article 2.

Article 2B: Halons

1. Each Party shall ensure that for the twelve-month period commencing on 1 January 1992, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group II of Annex A does not exceed, annually, its calculated level of consumption in 1986. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed, annually, its calculated level of production in 1986. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1986.

2. Each Party shall ensure that for the twelve-month period commencing on 1 January 1994, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group II of Annex A does not exceed zero. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed zero. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may, until 1 January 2002 exceed that limit by up to fifteen per cent of its calculated level of production in 1986; thereafter, it may exceed that limit by a quantity equal to the annual average of its production of the controlled substances in Group II of Annex A for basic domestic needs for the period 1995 to 1997 inclusive. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.

3. Each Party shall ensure that for the twelve-month period commencing on 1 January 2005 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group II of Annex A for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed fifty per cent of the annual average of its production of those substances for basic domestic needs for the period 1995 to 1997 inclusive.

4. Each Party shall ensure that for the twelve-month period commencing on 1 January 2010 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group II of Annex A for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed zero.

Article 2C: Other fully halogenated CFCs

1. Each Party shall ensure that for the twelve-month period commencing on 1 January 1993, its calculated level of consumption of the controlled substances in Group I of Annex B does not exceed, annually, eighty per cent of its calculated level of consumption in 1989. Each Party producing one or more of these substances shall, for the same period, ensure that its calculated level of production of the substances does not exceed, annually, eighty per cent of its calculated level of production in 1989. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1989.

2. Each Party shall ensure that for the twelve-month period commencing on 1 January 1994, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex B does not exceed, annually, twenty-five per cent of its calculated level of consumption in 1989. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed, annually, twenty-five per cent of its calculated level of production in 1989. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1989.

3. Each Party shall ensure that for the twelve-month period commencing on 1 January 1996, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex B does not exceed zero. Each Party producing one or more of these substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed zero. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may, until 1 January 2003 exceed that limit by up to fifteen per cent of its calculated level of production in 1989; thereafter, it may exceed that limit by a quantity equal to eighty per cent of the annual average of its production of the controlled substances in Group I of Annex B for basic domestic needs for the period 1998 to 2000 inclusive. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.

4. Each Party shall ensure that for the twelve-month period commencing on 1 January 2007 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group I of Annex B for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed fifteen per cent of the annual average of its production of those substances for basic domestic needs for the period 1998 to 2000 inclusive.

5. Each Party shall ensure that for the twelve-month period commencing on 1 January 2010 and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group I of Annex B for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed zero.

Article 2D: Carbon tetrachloride

1. Each Party shall ensure that for the twelve-month period commencing on 1 January 1995, its calculated level of consumption of the controlled substance in Group II of Annex B does not exceed, annually, fifteen per cent of its calculated level of consumption in 1989. Each Party producing the substance shall, for the same period, ensure that its calculated level of production of the substance does not exceed, annually, fifteen per cent of its calculated level of production in 1989. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1989.

2. Each Party shall ensure that for the twelve-month period commencing on 1 January 1996, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substance in Group II of Annex B does not exceed zero. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed zero. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to fifteen per cent of its calculated level of production in 1989. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.

Article 2E: 1,1,1-Trichloroethane (Methyl chloroform)

1. Each Party shall ensure that for the twelve-month period commencing on 1 January 1993, its calculated level of consumption of the controlled substance in Group III of Annex B does not exceed, annually, its calculated level of consumption in 1989. Each Party producing the substance shall, for the same period, ensure that its calculated level of production of the substance does not exceed, annually, its calculated level of production in 1989. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1989.

2. Each Party shall ensure that for the twelve-month period commencing on 1 January 1994, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substance in Group III of Annex B does not exceed, annually, fifty per cent of its calculated level of consumption in 1989. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed, annually, fifty per cent of its calculated level of production in 1989. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1989.

3. Each Party shall ensure that for the twelve-month period commencing on 1 January 1996, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substance in Group III of Annex B does not exceed zero. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed zero. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to fifteen per cent of its calculated level of production for 1989. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.

Article 2F: Hydrochlorofluorocarbons

1. Each Party shall ensure that for the twelve-month period commencing on 1 January 1996, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed, annually, the sum of:

a. Two point eight per cent of its calculated level of consumption in 1989 of the controlled substances in Group I of Annex A; and

b. Its calculated level of consumption in 1989 of the controlled substances in Group I of Annex C.

2. Each Party shall ensure that for the twelve month period commencing on 1 January 2004, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed, annually, sixty-five per cent of the sum referred to in paragraph 1 of this Article.

3. Each Party shall ensure that for the twelve-month period commencing on 1 January 2010, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed, annually, thirty-five per cent of the sum referred to in paragraph 1 of this Article.

4. Each Party shall ensure that for the twelve-month period commencing on 1 January 2015, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed, annually, ten per cent of the sum referred to in paragraph 1 of this Article.

5. Each Party shall ensure that for the twelve-month period commencing on 1 January 2020, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed, annually, zero point five per cent of the sum referred to in paragraph 1 of this Article. Such consumption shall, however, be restricted to the servicing of refrigeration and air conditioning equipment existing at that date.

6. Each Party shall ensure that for the twelve-month period commencing on 1 January 2030, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed zero.

7. As of 1 January 1996, each Party shall endeavour to ensure that:

a. The use of controlled substances in Group I of Annex C is limited to those applications where other more environmentally suitable alternative substances or technologies are not available;

b. The use of controlled substances in Group I of Annex C is not outside the areas of application currently met by controlled substances in Annexes A, B and C, except in rare cases for the protection of human life or human health; and

c. Controlled substances in Group I of Annex C are selected for use in a manner that minimizes ozone depletion, in addition to meeting other environmental, safety and economic considerations.

8. Each Party producing one or more of these substances shall ensure that for the twelve-month period commencing on 1 January 2004, and in each twelve-month period thereafter, its calculated level of production of the controlled substances in Group I of Annex C does not exceed, annually, the average of:

a. The sum of its calculated level of consumption in 1989 of the controlled substances in Group I of Annex C and two point eight per cent of its calculated level of consumption in 1989 of the controlled substances in Group I of Annex A; and

b. The sum of its calculated level of production in 1989 of the controlled substances in Group I of Annex C and two point eight per cent of its calculated level of production in 1989 of the controlled substances in Group I of Annex A.

However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to fifteen per cent of its calculated level of production of the controlled substances in Group I of Annex C as defined above.

Article 2G: Hydrobromofluorocarbons

Each Party shall ensure that for the twelve-month period commencing on 1 January 1996, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group II of Annex C does not exceed zero. Each Party producing the substances shall, for the same periods, ensure that its calculated level of production of the substances does not exceed zero. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.

Article 2H: Methyl bromide

1. Each Party shall ensure that for the twelve-month period commencing on 1 January 1995, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, its calculated level of consumption in 1991. Each Party producing the substance shall, for the same period, ensure that its calculated level of production of the substance does not exceed, annually, its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.

2. Each Party shall ensure that for the twelve-month period commencing on 1 January 1999, and in the twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, seventy-five per cent of its calculated level of consumption in 1991. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed, annually, seventy-five per cent of its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.

3. Each Party shall ensure that for the twelve-month period commencing on 1 January 2001, and in the twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, fifty per cent of its calculated level of consumption in 1991. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed, annually, fifty per cent of its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.

4. Each Party shall ensure that for the twelve-month period commencing on 1 January 2003, and in the twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed, annually, thirty per cent of its calculated level of consumption in 1991. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed, annually, thirty per cent of its calculated level of production in 1991. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to ten per cent of its calculated level of production in 1991.

5. Each Party shall ensure that for the twelve-month period commencing on 1 January 2005, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substance in Annex E does not exceed zero. Each Party producing the substance shall, for the same periods, ensure that its calculated level of production of the substance does not exceed zero. However, in order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may, until 1 January 2002 exceed that limit by up to fifteen per cent of its calculated level of production in 1991; thereafter, it may exceed that limit by a quantity equal to the annual average of its production of the controlled substance in Annex E for basic domestic needs for the period 1995 to 1998 inclusive. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be critical uses.

5 *bis*. Each Party shall ensure that for the twelve-month period commencing on 1 January 2005 and in each twelve-month period thereafter, its calculated level of production of the controlled substance in Annex E for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed eighty per cent of the annual average of its production of the substance for basic domestic needs for the period 1995 to 1998 inclusive.

5 *ter*. Each Party shall ensure that for the twelve-month period commencing on 1 January 2015 and in each twelve-month period thereafter, its calculated level of production of the controlled substance in Annex E for the basic domestic needs of the Parties operating under paragraph 1 of Article 5 does not exceed zero.

6. The calculated levels of consumption and production under this Article shall not include the amounts used by the Party for quarantine and pre-shipment applications.

Article 2I: Bromochloromethane

Each Party shall ensure that for the twelve-month period commencing on 1 January 2002, and in each twelve-month period thereafter, its calculated level of consumption and production of the controlled substance in Group III of Annex C does not exceed zero. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.

Article 3: Calculation of control levels

For the purposes of Articles 2, 2A to 2I and 5, each Party shall, for each group of substances in Annex A, Annex B, Annex C or Annex E determine its calculated levels of:

(a) Production by:

(i) multiplying its annual production of each controlled substance by the ozone depleting potential specified in respect of it in Annex A, Annex B, Annex C or Annex E;

(ii) adding together, for each such Group, the resulting figures;

(b) Imports and exports, respectively, by following, *mutatis mutandis*, the procedure set out in subparagraph (a); and

(c) Consumption by adding together its calculated levels of production and imports and subtracting its calculated level of exports as determined in accordance with subparagraphs (a) and (b). However, beginning on 1 January 1993, any export of controlled substances to non-Parties shall not be subtracted in calculating the consumption level of the exporting Party.

Article 4: Control of trade with non-Parties

1. As of 1 January 1990, each party shall ban the import of the controlled substances in Annex A from any State not party to this Protocol.

1 *bis*. Within one year of the date of the entry into force of this paragraph, each Party shall ban the import of the controlled substances in Annex B from any State not party to this Protocol.

1 *ter*. Within one year of the date of entry into force of this paragraph, each Party shall ban the import of any controlled substances in Group II of Annex C from any State not party to this Protocol.

1 *qua*. Within one year of the date of entry into force of this paragraph, each Party shall ban the import of the controlled substance in Annex E from any State not party to this Protocol.

1 *quin*. As of 1 January 2004, each Party shall ban the import of the controlled substances in Group I of Annex C from any State not party to this Protocol.

1 *sex*. Within one year of the date of entry into force of this paragraph, each Party shall ban the import of the controlled substance in Group III of Annex C from any State not party to this Protocol.

2. As of 1 January 1993, each Party shall ban the export of any controlled substances in Annex A to any State not party to this Protocol.

2 *bis*. Commencing one year after the date of entry into force of this paragraph, each Party shall ban the export of any controlled substances in Annex B to any State not party to this Protocol.

2 *ter*. Commencing one year after the date of entry into force of this paragraph, each Party shall ban the export of any controlled substances in Group II of Annex C to any State not party to this Protocol.

2 *qua*. Commencing one year of the date of entry into force of this paragraph, each Party shall ban the export of the controlled substance in Annex E to any State not party to this Protocol.

2 *quin*. As of 1 January 2004, each Party shall ban the export of the controlled substances in Group I of Annex C to any State not party to this Protocol.

2 *sex*. Within one year of the date of entry into force of this paragraph, each Party shall ban the export of the controlled substance in Group III of Annex C to any State not party to this Protocol.

3. By 1 January 1992, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of products containing controlled substances in Annex A. Parties that have not objected to the annex in accordance with those procedures shall ban, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

3 *bis*. Within three years of the date of the entry into force of this paragraph, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of products containing controlled substances in Annex B. Parties that have not objected to the annex in accordance with those procedures shall ban, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

3 *ter*. Within three years of the date of entry into force of this paragraph, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of products containing controlled substances in Group II of Annex C. Parties that have not objected to the annex in accordance with those procedures shall ban, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

4. By 1 January 1994, the Parties shall determine the feasibility of banning or restricting, from States not party to this Protocol, the import of products produced with, but not containing, controlled substances in Annex A. If determined feasible, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of such products. Parties that have not objected to the annex in accordance with those procedures shall ban, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

4 *bis*. Within five years of the date of the entry into force of this paragraph, the Parties shall determine the feasibility of banning or restricting, from States not party to this Protocol, the import of products produced with, but not containing, controlled substances in Annex B. If determined feasible, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of such products. Parties that have not objected to the annex in accordance with those procedures shall ban or restrict, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

4 *ter*. Within five years of the date of entry into force of this paragraph, the Parties shall determine the feasibility of banning or restricting, from States not party to this Protocol, the import of products produced with, but not containing, controlled substances in Group II of Annex C. If determined feasible, the Parties shall, following the procedures in Article 10 of the Convention, elaborate in an annex a list of such products. Parties that have not objected to the annex in accordance with those procedures shall ban or restrict, within one year of the annex having become effective, the import of those products from any State not party to this Protocol.

5. Each Party undertakes to the fullest practicable extent to discourage the export to any State not party to this Protocol of technology for producing and for utilizing controlled substances in Annexes A, B, C and E.

6. Each Party shall refrain from providing new subsidies, aid, credits, guarantees or insurance programmes for the export to States not party to this Protocol of products, equipment, plants or technology that would facilitate the production of controlled substances in Annexes A, B, C and E.

7. Paragraphs 5 and 6 shall not apply to products, equipment, plants or technology that improve the containment, recovery, recycling or destruction of controlled substances, promote the development of alternative substances, or otherwise contribute to the reduction of emissions of controlled substances in Annexes A, B, C and E.

8. Notwithstanding the provisions of this Article, imports and exports referred to in paragraphs 1 to 4 *ter* of this Article may be permitted from, or to, any State not party to this Protocol, if that State is determined, by a meeting of the Parties, to be in full compliance with Article 2, Articles 2A to 2I and this Article, and have submitted data to that effect as specified in Article 7.

9. For the purposes of this Article, the term "State not party to this Protocol" shall include, with respect to a particular controlled substance, a State or regional economic integration organization that has not agreed to be bound by the control measures in effect for that substance.

10. By 1 January 1996, the Parties shall consider whether to amend this Protocol in order to extend the measures in this Article to trade in controlled substances in Group I of Annex C and in Annex E with States not party to the Protocol.

Article 4A: Control of trade with Parties

1. Where, after the phase-out date applicable to it for a controlled substance, a Party is unable, despite having taken all practicable steps to comply with its obligation under the Protocol, to cease production of that substance for domestic consumption, other than for uses agreed by the Parties to be essential, it shall ban the export of used, recycled and reclaimed quantities of that substance, other than for the purpose of destruction.

2. Paragraph 1 of this Article shall apply without prejudice to the operation of Article 11 of the Convention and the non-compliance procedure developed under Article 8 of the Protocol.

Article 4B: Licensing

1. Each Party shall, by 1 January 2000 or within three months of the date of entry into force of this Article for it, whichever is the later, establish and implement a system for licensing the import and export of new, used, recycled and reclaimed controlled substances in Annexes A, B, C and E.

2. Notwithstanding paragraph 1 of this Article, any Party operating under paragraph 1 of Article 5 which decides it is not in a position to establish and implement a system for licensing the import and export of controlled substances in Annexes C and E, may delay taking those actions until 1 January 2005 and 1 January 2002, respectively.

3. Each Party shall, within three months of the date of introducing its licensing system, report to the Secretariat on the establishment and operation of that system.

4. The Secretariat shall periodically prepare and circulate to all Parties a list of the Parties that have reported to it on their licensing systems and shall forward this information to the Implementation Committee for consideration and appropriate recommendations to the Parties.

Article 5: Special situation of developing countries

1. Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances in Annex A is less than 0.3 kilograms per capita on the date of the entry into force of the Protocol for it, or any time thereafter until 1 January 1999, shall, in order to meet its basic domestic needs, be entitled to delay for ten years its compliance with the control measures set out in Articles 2A to 2E*,* provided that any further amendments to the adjustments or Amendment adopted at the Second Meeting of the Parties in London, 29 June 1990, shall apply to the Parties operating under this paragraph after the review provided for in paragraph 8 of this Article has taken place and shall be based on the conclusions of that review.

1 *bis*. The Parties shall, taking into account the review referred to in paragraph 8 of this Article, the assessments made pursuant to Article 6 and any other relevant information, decide by 1 January 1996, through the procedure set forth in paragraph 9 of Article 2:

a. With respect to paragraphs 1 to 6 of Article 2F, what base year, initial levels, control schedules and phase-out date for consumption of the controlled substances in Group I of Annex C will apply to Parties operating under paragraph 1 of this Article;

b. With respect to Article 2G, what phase-out date for production and consumption of the controlled substances in Group II of Annex C will apply to Parties operating under paragraph 1 of this Article; and

c. With respect to Article 2H, what base year, initial levels and control schedules for consumption and production of the controlled substance in Annex E will apply to Parties operating under paragraph 1 of this Article.

2. However, any Party operating under paragraph 1 of this Article shall exceed neither an annual calculated level of consumption of the controlled substances in Annex A of 0.3 kilograms per capita nor an annual calculated level of consumption of controlled substances of Annex B of 0.2 kilograms per capita.

3. When implementing the control measures set out in Articles 2A to 2E, any Party operating under paragraph 1 of this Article shall be entitled to use:

a. For controlled substances under Annex A, either the average of its annual calculated level of consumption for the period 1995 to 1997 inclusive or a calculated level of consumption of 0.3 kilograms per capita, whichever is the lower, as the basis for determining its compliance with the control measures relating to consumption.

b. For controlled substances under Annex B, the average of its annual calculated level of consumption for the period 1998 to 2000 inclusive or a calculated level of consumption of 0.2 kilograms per capita, whichever is the lower, as the basis for determining its compliance with the control measures relating to consumption.

c. For controlled substances under Annex A, either the average of its annual calculated level of production for the period 1995 to 1997 inclusive or a calculated level of production of 0.3 kilograms per capita, whichever is the lower, as the basis for determining its compliance with the control measures relating to production.

d. For controlled substances under Annex B, either the average of its annual calculated level of production for the period 1998 to 2000 inclusive or a calculated level of production of 0.2 kilograms per capita, whichever is the lower, as the basis for determining its compliance with the control measures relating to production.

4. If a Party operating under paragraph 1 of this Article, at any time before the control measures obligations in Articles 2A to 2I become applicable to it, finds itself unable to obtain an adequate supply of controlled substances, it may notify this to the Secretariat. The Secretariat shall forthwith transmit a copy of such notification to the Parties, which shall consider the matter at their next Meeting, and decide upon appropriate action to be taken.

5. Developing the capacity to fulfil the obligations of the Parties operating under paragraph 1 of this Article to comply with the control measures set out in Articles 2A to 2E and Article 2I, and any control measures in Articles 2F to 2H that are decided pursuant to paragraph 1 *bis* of this Article, and their implementation by those same Parties will depend upon the effective implementation of the financial co-operation as provided by Article 10 and the transfer of technology as provided by Article 10A.

6. Any Party operating under paragraph 1 of this Article may, at any time, notify the Secretariat in writing that, having taken all practicable steps it is unable to implement any or all of the obligations laid down in Articles 2A to 2E and Article 2I, or any or all obligations in Articles 2F to 2H that are decided pursuant to paragraph 1 *bis* of this Article, due to the inadequate implementation of Articles 10 and 10A. The Secretariat shall forthwith transmit a copy of the notification to the Parties, which shall consider the matter at their next Meeting, giving due recognition to paragraph 5 of this Article and shall decide upon appropriate action to be taken.

7. During the period between notification and the Meeting of the Parties at which the appropriate action referred to in paragraph 6 above is to be decided, or for a further period if the Meeting of the Parties so decides, the non-compliance procedures referred to in Article 8 shall not be invoked against the notifying Party.

8. A Meeting of the Parties shall review, not later than 1995, the situation of the Parties operating under paragraph 1 of this Article, including the effective implementation of financial co-operation and transfer of technology to them, and adopt such revisions that may be deemed necessary regarding the schedule of control measures applicable to those Parties.

8 *bis*. Based on the conclusions of the review referred to in paragraph 8 above:

a. With respect to the controlled substances in Annex A, a Party operating under paragraph 1 of this Article shall, in order to meet its basic domestic needs, be entitled to delay for ten years its

compliance with the control measures adopted by the Second Meeting of the Parties in London, 29 June 1990, and reference by the Protocol to Articles 2A and 2B shall be read accordingly;

b. With respect to the controlled substances in Annex B, a Party operating under paragraph 1 of this Article shall, in order to meet its basic domestic needs, be entitled to delay for ten years its compliance with the control measures adopted by the Second Meeting of the Parties in London, 29 June 1990, and reference by the Protocol to Articles 2C to 2E shall be read accordingly.

8 *ter*. Pursuant to paragraph 1 *bis* above:

a. Each Party operating under paragraph 1 of this Article shall ensure that for the twelve-month period commencing on 1 January 2016, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed, annually, its calculated level of consumption in 2015. As of 1 January 2016 each Party operating under paragraph 1 of this Article shall comply with the control measures set out in paragraph 8 of Article 2F and, as the basis for its compliance with these control measures, it shall use the average of its calculated levels of production and consumption in 2015;

b. Each Party operating under paragraph 1 of this Article shall ensure that for the twelve-month period commencing on 1 January 2040, and in each twelve-month period thereafter, its calculated level of consumption of the controlled substances in Group I of Annex C does not exceed zero;

c. Each Party operating under paragraph 1 of this Article shall comply with Article 2G;

d. With regard to the controlled substance contained in Annex E:

(i) As of 1 January 2002 each Party operating under paragraph 1 of this Article shall comply with the control measures set out in paragraph 1 of Article 2H and, as the basis for its compliance with these control measures, it shall use the average of its annual calculated level of consumption and production, respectively, for the period of 1995 to 1998 inclusive;

(ii) Each Party operating under paragraph 1 of this Article shall ensure that for the twelve-month period commencing on 1 January 2005, and in each twelve-month period thereafter, its calculated levels of consumption and production of the controlled substance in Annex E do not exceed, annually, eighty per cent of the average of its annual calculated levels of consumption and production, respectively, for the period of 1995 to 1998 inclusive;

(iii) Each Party operating under paragraph 1 of this Article shall ensure that for the twelve-month period commencing on 1 January 2015 and in each twelve-month period thereafter, its calculated levels of consumption and production of the controlled substance in Annex E do not exceed zero. This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be critical uses;

(iv) The calculated levels of consumption and production under this subparagraph shall not include the amounts used by the Party for quarantine and pre-shipment applications.

9. Decisions of the Parties referred to in paragraph 4, 6 and 7 of this Article shall be taken according to the same procedure applied to decision-making under Article 10.

Article 6: Assessment and review of control measures

Beginning in 1990, and at least every four years thereafter, the Parties shall assess the control measures provided for in Article 2 and Articles 2A to 2I on the basis of available scientific, environmental, technical and economic information. At least one year before each assessment, the Parties shall convene appropriate panels of experts qualified in the fields mentioned and determine the composition and terms of reference of any such panels. Within one year of being convened, the panels will report their conclusions, through the Secretariat, to the Parties.

Article 7: Reporting of data

1. Each Party shall provide to the Secretariat, within three months of becoming a Party, statistical data on its production, imports and exports of each of the controlled substances in Annex A for the year 1986, or the best possible estimates of such data where actual data are not available.

2. Each Party shall provide to the Secretariat statistical data on its production, imports and exports of each of the controlled substances

– in Annex B and Annexes I and II of Group C for the year 1989;

– in Annex E, for the year 1991,

or the best possible estimates of such data where actual data are not available, not later than three months after the date when the provisions set out in the Protocol with regard to the substances in Annexes B, C and E respectively enter into force for that Party.

3. Each Party shall provide to the Secretariat statistical data on its annual production (as defined in paragraph 5 of Article 1) of each of the controlled substances listed in Annexes A, B, C and E and, separately, for each substance,

– Amounts used for feedstocks,

– Amounts destroyed by technologies approved by the Parties, and

– Imports from and exports to Parties and non-Parties respectively,

for the year during which provisions concerning the substances in Annexes A, B, C and E respectively entered into force for that Party and for each year thereafter. Each Party shall provide to the Secretariat statistical data on the annual amount of the controlled substance listed in Annex E used for quarantine and pre-shipment applications. Data shall be forwarded not later than nine months after the end of the year to which the data relate.

3 *bis.* Each Party shall provide to the Secretariat separate statistical data of its annual imports and exports of each of the controlled substances listed in Group II of Annex A and Group I of Annex C that have been recycled.

4. For Parties operating under the provisions of paragraph 8 (a) of Article 2, the requirements in paragraphs 1, 2, 3 and 3 *bi*s of this Article in respect of statistical data on imports and exports shall be satisfied if the regional economic integration organization concerned provides data on imports and exports between the organization and States that are not members of that organization.

Article 8: Non-compliance

The Parties, at their first meeting, shall consider and approve procedures and institutional mechanisms for determining non-compliance with the provisions of this Protocol and for treatment of Parties found to be in non-compliance.

Article 9: Research, development, public awareness and exchange of information

1. The Parties shall co-operate, consistent with their national laws, regulations and practices and taking into account in particular the needs of developing countries, in promoting, directly or through competent international bodies, research, development and exchange of information on:

a. best technologies for improving the containment, recovery, recycling, or destruction of controlled substances or otherwise reducing their emissions;

b. possible alternatives to controlled substances, to products containing such substances, and to products manufactured with them; and

c. costs and benefits of relevant control strategies.

2. The Parties, individually, jointly or through competent international bodies, shall co-operate in promoting public awareness of the environmental effects of the emissions of controlled substances and other substances that deplete the ozone layer.

3. Within two years of the entry into force of this Protocol and every two years thereafter, each Party shall submit to the Secretariat a summary of the activities it has conducted pursuant to this Article.

Article 10: Financial mechanism

1. The Parties shall establish a mechanism for the purposes of providing financial and technical co-operation, including the transfer of technologies, to Parties operating under paragraph 1 of Article 5 of this Protocol to enable their compliance with the control measures set out in Articles 2A to 2E and Article 2I, and any control measures in Articles 2F to 2H that are decided pursuant to paragraph 1 *bis* of Article 5 of the Protocol. The mechanism, contributions to which shall be additional to other financial transfers to Parties operating under that paragraph, shall meet all agreed incremental costs of such Parties in order to enable their compliance with the control measures of the Protocol. An indicative list of the categories of incremental costs shall be decided by the meeting of the Parties.

2. The mechanism established under paragraph 1 shall include a Multilateral Fund. It may also include other means of multilateral, regional and bilateral co-operation.

3. The Multilateral Fund shall:

a. Meet, on a grant or concessional basis as appropriate, and according to criteria to be decided upon by the Parties, the agreed incremental costs;

b. Finance clearing-house functions to:

(i) Assist Parties operating under paragraph 1 of Article 5, through country specific studies and other technical co-operation, to identify their needs for co-operation;

(ii) Facilitate technical co-operation to meet these identified needs;

(iii) Distribute, as provided for in Article 9, information and relevant materials, and hold workshops, training sessions, and other related activities, for the benefit of Parties that are developing countries; and

(iv) Facilitate and monitor other multilateral, regional and bilateral co-operation available to Parties that are developing countries;

c. Finance the secretarial services of the Multilateral Fund and related support costs.

4. The Multilateral Fund shall operate under the authority of the Parties who shall decide on its overall policies.

5. The Parties shall establish an Executive Committee to develop and monitor the implementation of specific operational policies, guidelines and administrative arrangements, including the disbursement of resources, for the purpose of achieving the objectives of the Multilateral Fund. The Executive Committee shall discharge its tasks and responsibilities, specified in its terms of reference as agreed by the Parties, with the co-operation and assistance of the International Bank for Reconstruction and Development (World Bank), the United Nations Environment Programme, the United Nations Development Programme or other appropriate agencies depending on their respective areas of expertise. The members of the Executive Committee, which shall be selected on the basis of a balanced representation of the Parties operating under paragraph 1 of Article 5 and of the Parties not so operating, shall be endorsed by the Parties.

6. The Multilateral Fund shall be financed by contributions from Parties not operating under paragraph 1 of Article 5 in convertible currency or, in certain circumstances, in kind and/or in national currency, on the basis of the United Nations scale of assessments. Contributions by other Parties shall be encouraged. Bilateral and, in particular cases agreed by a decision of the Parties, regional co-operation may, up to a percentage and consistent with any criteria to be specified by decision of the Parties, be considered as a contribution to the Multilateral Fund, provided that such co-operation, as a minimum:

a. Strictly relates to compliance with the provisions of this Protocol;

b. Provides additional resources; and

c. Meets agreed incremental costs.

7. The Parties shall decide upon the programme budget of the Multilateral Fund for each fiscal period and upon the percentage of contributions of the individual Parties thereto.

8. Resources under the Multilateral Fund shall be disbursed with the concurrence of the beneficiary Party.

9. Decisions by the Parties under this Article shall be taken by consensus whenever possible. If all efforts at consensus have been exhausted and no agreement reached, decisions shall be adopted by a two-thirds majority vote of the Parties present and voting, representing a majority of the Parties operating under paragraph 1 of Article 5 present and voting and a majority of the Parties not so operating present and voting.

10. The financial mechanism set out in this Article is without prejudice to any future arrangements that may be developed with respect to other environmental issues.

Article 10A: Transfer of technology

Each Party shall take every practicable step, consistent with the programmes supported by the financial mechanism, to ensure:

a. that the best available, environmentally safe substitutes and related technologies are expeditiously transferred to Parties operating under paragraph 1 of Article 5; and

b. that the transfers referred to in subparagraph (a) occur under fair and most favourable conditions.

Article 11: Meetings of the parties

1. The Parties shall hold meetings at regular intervals. The Secretariat shall convene the first meeting of the Parties not later than one year after the date of the entry into force of this Protocol and in conjunction with a meeting of the Conference of the Parties to the Convention, if a meeting of the latter is scheduled within that period.

2. Subsequent ordinary meetings of the parties shall be held, unless the Parties otherwise decide, in conjunction with meetings of the Conference of the Parties to the Convention. Extraordinary meetings of the Parties shall be held at such other times as may be deemed necessary by a meeting of the Parties, or at the written request of any Party, provided that within six months of such a request being communicated to them by the Secretariat, it is supported by at least one third of the Parties.

3. The Parties, at their first meeting, shall:

a. adopt by consensus rules of procedure for their meetings;

b. adopt by consensus the financial rules referred to in paragraph 2 of Article 13;

c. establish the panels and determine the terms of reference referred to in Article 6;

d. consider and approve the procedures and institutional mechanisms specified in Article 8; and

e. begin preparation of workplans pursuant to paragraph 3 of Article 10.

4. The functions of the meetings of the Parties shall be to:

a. review the implementation of this Protocol;

b. decide on any adjustments or reductions referred to in paragraph 9 of Article 2;

c. decide on any addition to, insertion in or removal from any annex of substances and on related control measures in accordance with paragraph 10 of Article 2;

d. establish, where necessary, guidelines or procedures for reporting of information as provided for in Article 7 and paragraph 3 of Article 9;

e. review requests for technical assistance submitted pursuant to paragraph 2 of Article 10;

f. review reports prepared by the secretariat pursuant to subparagraph (c) of Article 12;

g. assess, in accordance with Article 6, the control measures;

h. consider and adopt, as required, proposals for amendment of this Protocol or any annex and for any new annex;

i. consider and adopt the budget for implementing this Protocol; and

j. consider and undertake any additional action that may be required for the achievement of the purposes of this Protocol.

5. The United Nations, its specialized agencies and the International Atomic Energy Agency, as well as any State not party to this Protocol, may be represented at meetings of the Parties as observers. Any body or agency, whether national or international, governmental or non-governmental, qualified in fields relating to the protection of the ozone layer which has informed the secretariat of its wish to be represented at a meeting of the Parties as an observer may be admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the Parties.

Article 12: Secretariat

For the purposes of this Protocol, the Secretariat shall:

a. arrange for and service meetings of the Parties as provided for in Article 11;

b. receive and make available, upon request by a Party, data provided pursuant to Article 7;

c. prepare and distribute regularly to the Parties reports based on information received pursuant to Articles 7 and 9;

d. notify the Parties of any request for technical assistance received pursuant to Article 10 so as to facilitate the provision of such assistance;

e. encourage non-Parties to attend the meetings of the Parties as observers and to act in accordance with the provisions of this Protocol;

f. provide, as appropriate, the information and requests referred to in subparagraphs (c) and (d) to such non-party observers; and

g. perform such other functions for the achievement of the purposes of this Protocol as may be assigned to it by the Parties.

Article 13: Financial provisions

1. The funds required for the operation of this Protocol, including those for the functioning of the Secretariat related to this Protocol, shall be charged exclusively against contributions from the Parties.

2. The Parties, at their first meeting, shall adopt by consensus financial rules for the operation of this Protocol.

Article 14: Relationship of this Protocol to the Convention

Except as otherwise provided in this Protocol, the provisions of the Convention relating to its protocols shall apply to this Protocol.

Article 15: Signature

This Protocol shall be open for signature by States and by regional economic integration organizations in Montreal on 16 September 1987, in Ottawa from 17 September 1987 to 16 January 1988, and at United Nations Headquarters in New York from 17 January 1988 to 15 September 1988.

Article 16: Entry into force

1. This Protocol shall enter into force on 1 January 1989, provided that at least eleven instruments of ratification, acceptance, approval of the Protocol or accession thereto have been deposited by States or regional economic integration organizations representing at least two-thirds of 1986 estimated global consumption of the controlled substances, and the provisions of paragraph 1 of Article 17 of the Convention have been fulfilled. In the event that these conditions have not been fulfilled by that date, the Protocol shall enter into force on the ninetieth day following the date on which the conditions have been fulfilled.

2. For the purposes of paragraph 1, any such instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by member States of such organization.

3. After the entry into force of this Protocol, any State or regional economic integration organization shall become a Party to it on the ninetieth day following the date of deposit of its instrument of ratification, acceptance, approval or accession.

Article 17: Parties joining after entry into force

Subject to Article 5, any State or regional economic integration organization which becomes a Party to this Protocol after the date of its entry into force, shall fulfil forthwith the sum of the obligations under Article 2, as well as under Articles 2A to 2I and Article 4, that apply at that date to the States and regional economic integration organizations that became Parties on the date the Protocol entered into force.

Article 18: Reservations

No reservations may be made to this Protocol.

Article 19: Withdrawal

Any Party may withdraw from this Protocol by giving written notification to the Depositary at any time after four years of assuming the obligations specified in paragraph 1 of Article 2A. Any such withdrawal shall take effect upon expiry of one year after the date of its receipt by the Depositary, or on such later date as may be specified in the notification of the withdrawal.

Article 20: Authentic texts

The original of this Protocol, of which the Arabic, Chinese, English, French, Russian and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations.

IN WITNESS WHEREOF THE UNDERSIGNED, BEING DULY AUTHORIZED TO THAT EFFECT, HAVE SIGNED THIS PROTOCOL.

DONE AT MONTREAL THIS SIXTEENTH DAY OF SEPTEMBER, ONE THOUSAND NINE HUNDRED AND EIGHTY SEVEN.

Annex A: Controlled substances

Group	Substance	Ozone-Depleting Potential*
Group I		
$CFCl_3$	(CFC-11)	1.0
CF_2Cl_2	(CFC-12)	1.0
$C_2F_3Cl_3$	(CFC-113)	0.8
$C_2F_4Cl_2$	(CFC-114)	1.0

C_2F_5Cl	(CFC-115)	0.6
Group II		
CF_2BrCl	(halon-1211)	3.0
CF_3Br	(halon-1301)	10.0
$C_2F_4Br_2$	(halon-2402)	6.0

* These ozone depleting potentials are estimates based on existing knowledge and will be reviewed and revised periodically.

Annex B: Controlled substances

Group	Substance	Ozone-Depleting Potential
Group I		
CF_3Cl	(CFC-13)	1.0
C_2FCl_5	(CFC-111)	1.0
$C_2F_2Cl_4$	(CFC-112)	1.0
C_3FCl_7	(CFC-211)	1.0
$C_3F_2Cl_6$	(CFC-212)	1.0
$C_3F_3Cl_5$	(CFC-213)	1.0
$C_3F_4Cl_4$	(CFC-214)	1.0
$C_3F_5Cl_3$	(CFC-215)	1.0
$C_3F_6Cl_2$	(CFC-216)	1.0
C_3F_7Cl	(CFC-217)	1.0
Group II		
CCl_4	carbon tetrachloride	1.1
Group III		
$C_2H_3Cl_3$*	1,1,1-trichloroethane* (methyl chloroform)	0.1

* This formula does not refer to 1,1,2-trichloroethane.

Annex C: Controlled substances

Group	Substance	Number of isomers	Ozone-Depleting Potential
Group I			
$CHFCl_2$	(HCFC-21)**	1	0.04
CHF_2Cl	(HCFC-22)**	1	0.055
CH_2FCl	(HCFC-31)	1	0.02
C_2HFCl_4	(HCFC-121)	2	0.01–0.04
$C_2HF_2Cl_3$	(HCFC-122)	3	0.02–0.08
$C_2HF_3Cl_2$	(HCFC-123)	3	0.02–0.06
$CHCl_2CF_3$	(HCFC-123)**	–	0.02
C_2HF_4Cl	(HCFC-124)	2	0.02–0.04
$CHFClCF_3$	(HCFC-124)**	–	0.022
$C_2H_2FCl_3$	(HCFC-131)	3	0.007–0.05
$C_2H_2F_2Cl_2$	(HCFC-132)	4	0.008–0.05
$C_2H_2F_3Cl$	(HCFC-133)	3	0.02–0.06
$C_2H_3FCl_2$	(HCFC-141)	3	0.005–0.07
CH_3CFCl_2	(HCFC-141b)**	–	0.11
$C_2H_3F_2Cl$	(HCFC-142)	3	0.008–0.07
CH_3CF_2Cl	(HCFC-142b)**	–	0.065
C_2H_4FCl	(HCFC-151)	2	0.003–0.005
C_3HFCl_6	(HCFC-221)	5	0.015–0.07
$C_3HF_2Cl_5$	(HCFC-222)	9	0.01–0.09
$C_3HF_3Cl_4$	(HCFC-223)	12	0.01–0.08
$C_3HF_4Cl_3$	(HCFC-224)	12	0.01–0.09
$C_3HF_5Cl_2$	(HCFC-225)	9	0.02–0.07
$CF_3CF_2CHCl_2$	(HCFC-225ca)**	–	0.025
CF_2ClCF_2CHClF	(HCFC-225cb)**	–	0.033
C_3HF_6Cl	(HCFC-226)	5	0.02–0.10

$C_3H_2FCl_5$	(HCFC-231)	9	0.05–0.09
$C_3H_2F_2Cl_4$	(HCFC-232)	16	0.008–0.10
$C_3H_2F_3Cl_3$	(HCFC-233)	18	0.007–0.23
$C_3H_2F_4Cl_2$	(HCFC-234)	16	0.01–0.28
$C_3H_2F_5Cl$	(HCFC-235)	9	0.03–0.52
$C_3H_3FCl_4$	(HCFC-241)	12	0.004–0.09
$C_3H_3F_2Cl_3$	(HCFC-242)	18	0.005–0.13
$C_3H_3F_3Cl_2$	(HCFC-243)	18	0.007–0.12
$C_3H_3F_4Cl$	(HCFC-244)	12	0.009–0.14
$C_3H_4FCl_3$	(HCFC-251)	12	0.001–0.01
$C_3H_4F_2Cl_2$	(HCFC-252)	16	0.005–0.04
$C_3H_4F_3Cl$	(HCFC-253)	12	0.003–0.03
$C_3H_5FCl_2$	(HCFC-261)	9	0.002–0.02
$C_3H_5F_2Cl$	(HCFC-262)	9	0.002–0.02
C_3H_6FCl	(HCFC-271)	5	0.001–0.03
Group II			
$CHFBr_2$		1	1.00
CHF_2Br	(HBFC-22B1)	1	0.74
CH_2FBr		1	0.73
C_2HFBr_4		2	0.3–0.8
$C_2HF_2Br_3$		3	0.5–1.8
$C_2HF_3Br_2$		3	0.4–1.6
C_2HF_4Br		2	0.7–1.2
$C_2H_2FBr_3$		3	0.1–1.1
$C_2H_2F_2Br_2$		4	0.2–1.5
$C_2H_2F_3Br$		3	0.7–1.6

$C_2H_3FBr_2$		3	0.1–1.7
$C_2H_3F_2Br$		3	0.2–1.1
C_2H_4FBr		2	0.07–0.1
C_3HFBr_6		5	0.3–1.5
$C_3HF_2Br_5$		9	0.2–1.9
$C_3HF_3Br_4$		12	0.3–1.8
$C_3HF_4Br_3$		12	0.5–2.2
$C_3HF_5Br_2$		9	0.9–2.0
C_3HF_6Br		5	0.7–3.3
$C_3H_2FBr_5$		9	0.1–1.9
$C_3H_2F_2Br_4$		16	0.2–2.1
$C_3H_2F_3Br_3$		18	0.2–5.6
$C_3H_2F_4Br_2$		16	0.3–7.5
$C_3H_2F_5Br$		8	0.9–14.0
$C_3H_3FBr_4$		12	0.08–1.9
$C_3H_3F_2Br_3$		18	0.1–3.1
$C_3H_3F_3Br_2$		18	0.1–2.5
$C_3H_3F_4Br$		12	0.3–4.4
$C_3H_4FBr_3$		12	0.03–0.3
$C_3H_4F_2Br_2$		16	0.1–1.0
$C_3H_4F_3Br$		12	0.07–0.8
$C_3H_5FBr_2$		9	0.04–0.4
$C_3H_5F_2Br$		9	0.07–0.8
C_3H_6FBr		5	0.02–0.7
Group III			
CH_2BrCl	bromochloromethane	1	0.12

* Where a range of ODPs is indicated, the highest value in that range shall be used for the purposes of the Protocol. The ODPs listed as a single value have been determined from

calculations based on laboratory measurements. Those listed as a range are based on estimates and are less certain. The range pertains to an isomeric group. The upper value is the estimate of the ODP of the isomer with the highest ODP, and the lower value is the estimate of the ODP of the isomer with the lowest ODP.

** Identifies the most commercially viable substances with ODP values listed against them to be used for the purposes of the Protocol.

Annex D:* A list of products** containing controlled substances specified in Annex A

	Products		Customs code number
1.	Automobile and truck air conditioning units (whether incorporated in vehicles or not)		.....
2.	Domestic and commercial refrigeration and air conditioning/heat pump equipment***		.....
	e.g.	Refrigerators	.....
		Freezers	.....
		Dehumidifiers	.....
		Water coolers	.....
		Ice machines	.....
		Air conditioning and heat pump units	.....
3.	Aerosol products, except medical aerosols		.....
4.	Portable fire extinguisher		.....
5.	Insulation boards, panels and pipe covers		.....
6.	Pre-polymers		.....

* This Annex was adopted by the Third Meeting of the Parties in Nairobi, 21 June 1991 as required by paragraph 3 of Article 4 of the Protocol.

** Though not when transported in consignments of personal or household effects or in similar non-commercial situations normally exempted from customs attention. *** When containing controlled substances in Annex A as a refrigerant and/or in insulating material of the product.

Annex E: Controlled substance

Group	Substance	Ozone-Depleting Potential
Group I		
CH_3Br	methyl bromide	0.6

This text contains the latest version of the Montreal Protocol on Substances that Deplete the Ozone Layer, updated to March 2000 to include the cumulative amendments to various articles adopted by the Parties at their Second, Fourth, Ninth and Eleventh Meetings. It includes also the adjustments in levels of production and consumption of the controlled substances listed in annexes A, B, C and E to the Protocol, as decided

by the Parties on the basis of assessment made in pursuance of article 6 of the Protocol at the Second, Fourth, Seventh, Ninth and Eleventh Meetings. It should be noted that while adjustments to the Protocol enter into force automatically six months after the date of official notification by the Depositary, each set of amendments is subject to ratification and enters into force and becomes binding for Parties to such amendments only after it has been ratified by a minimum number of Parties.

Separate texts of the adjustments and amendments to the Protocol as agreed by the Parties to the Protocol at meetings in London, Copenhagen, Vienna, Montreal and Beijing are available from either the Depositary, the United Nations Secretary-General, the Ozone Secretariat in UNEP or the Treaties Sections of the Ministries of Foreign Affairs of various Governments.

Ozone Secretariat
United Nations Environment Programme
P. O. Box 30552, Nairobi, Kenya
Tel: (254 2) 62 3850 □ Fax: (254 2) 62 3913/62 3601
Email: Ozoneinfo@unep.org

ISBN: 92-807-1888-6

ANNEX V. THAILAND PUBLIC HEALTH ACT 1992

Public Health Act, B.E.2535

BHUMIBOL ADULYADEJ REX.

Given on the 29th day of March B.E. 2535
Being the 47th year of the Present Reign.

His Majesty King Bhumibol Adulyadej has been graciously pleased to proclaim that,

Whereas it is expedient to revise the law on public health and the law on control of use of fecal matter as Fertilizer;

Be it, therefore, enacted by His Majesty the King, by and with advice and consent of the National Legislative Assembly in the capacity as the Parliament, as follows

SECTION 1. This Act shall be cited "Public Health Act, B:E. 2535"

SECTION 2. This Act shall come into force on the date immediately following that of its promulgation in the Royal Government Gazette.

SECTION 3. The following shall be repealed

(1) Public Health Act, B.E. 2484 ;
(2) Public Health Act (No.2), B.E. 2495 ;
(3) Public Health Act (No.3), B.E. 2497 ;
(4) Public Health Act (No.4), B.E. 2505 ;
(5) Public Health Act (No.5), B.E. 2527 ;
(6) Control of Use Fecal Matter as Fertilizer Act, B.E. 2480 ;
(7) Control of Use of Fecal Matter as Fertilizer Act, (No.2), B.E. 2484 ;
(8) Control of Use of Fecal Matter as Fertilizer Act, (No.3), B.E. 2497. SECTION 4. In this Act,

"sewage" means excrement or urine and including any other thing that is filthy or gives foul odor;
"Solid waste" means waste paper, waste cloth, waste food, waste commodity, plastic bag, food container, soot, animal dung or carcass, including other thing swept away from roads, market places, animal farms, or other places;
"public place or way" means a place or way which is not privately owned and the people can use or pass;
"building" means a house, shelter, shop, raft, warehouse, office, or other erection that persons may enter to stay or use;
"market place" means a place ordinarily arranged for merchants to assemble to offer for sale goods consisting of animal, meat, vegetable, fruit, fresh or already prepared or cooked food, or perishable foodstuff, with or without other kinds of goods for sale, and includes an area arranged for merchants to assemble to offer said goods for sale regularly or from time to time or on appointed dates ;
"place where meals are sole" means any building, place, or area which is not public place or way, arranged for the preparation or cooking of meals to be served to buyers for consumption at the place or taken away;
"place where foodstuff is stored" means any building, place, or area which is not a public place or way, arranged for the storage of food in fresh, dry, or any other state for sale to buyers for consumption after processing ;
"local government" means a municipality, sanitary district, provincial administrative organization, Bangkok Metropolis, Pattaya City, or other local government designated a local government by the law;
"local provisions" means the provisions, ordinance, or by-law issued by the local government;
"local official" means
(1) the mayor, for the area in the.municipal limits ;
(2) the sanitary committee chirman, for the area in the sanitary district ;
(3) the governor, for the area in the provincial administrative organization ;
(4) Governor of Bangkok Metropolis, for the area in Bangkok Metropolis;
(5) City Clerk of Pattaya City, for the area in Pattaya City ;
(6) the local chief-administrate of other local administrative organization designated a local government by the law, for the area in such local government ;
"public health official" means an official appointed to execute this Act;
"Committee" means the Public Health Committee;
"Minister" means the minister in charge and control of the execution of this Act.

SECTION 5. Minister of Public Health shall be in charge and control .of the execution of this Act and shall have powers to appoint public health officials and issue ministerial regulations fixing rate of fees or granting exemption from Fees and prescribing other requirements for the execution of this Act.

The ministerial regulations shall become effective upon their promulgation in the Royal Goverment Gazette.

CHAPTER 1
General Provisions

SECTION 6. For the purpose of execution of this Act, the Minister shall with advice of the Committee, have powers to issue ministerial regulations

(1) prescribing rules, procedures, and measures for controlling or overseeing activities or operations on matters under this Act ;

(2) prescribing living standards suitable to the livelihood of the population and procedures for controlling or overseeing or remedying things affecting the living standard suitable to the livelihood of the population.

Ministerial regulations pursuant to paragraph one may be issued for enforcement in every locality or in any particular locality.

SECTION 7. When there is a ministerial regulation issued under Section 6 enforced in any locality, the local government or local official which has activity or operation under said ministerial regulation in the jurisdiction of such locality shall operate in accordance with provisions of the ministerial regulation. In this connection, if necessary, the local government may issue local provisions or amend the local provisions already in force before the ministerial regulation was issued under Section 6, prescribing details of operation in such locality to be in accordance with said ministerial regulation.

If the local provisions of any locality are inconsistent with or contrary to a ministerial regulation issued under Section 6, such ministerial regulation shall prevail. However, when it Is necessary of there is a special reason of the specific locality, the local government may issue local provisions on any matter in inconsistence with, or contrary to the provisions contained In aministerial regulation issued under Section 6, upon approval by the Comunittee and permission by the Minister.

SECTION 8. In the event there occurs or there is cause to believe that serious damage will be caused to the living condition suitable to the livelihood of the population and urgent remedy or prevention is required, the Director-General of-Health Department shall have powers to order the owner of materials or persons involved in the causing or possibly said damage to cease action or take any action to remedy or prevent such damage as deemed appropriate.

If the person, who received an order pursuant to paragraph one failed to comply with the order within a reasonable period of time, the Director-General of Health Department may order the public health official to take any action to remedy or prevent said damage instead. In such case, the public health official shall take care necessary under the circumstance and the person who received said order must pay expenses incurred therein.

In a province other than Bangkok Metropolis, the Director-General of Health Department shall instruct the provincial governor to order the provincial public health officer to comply with the provisions in paragraph two for the area in such province.

CHAPTER 2
Public Health Committee

SECTION 9. There shall be one committee called "Public Health Committee" made up of Permanent Secretary of Public Health Ministry as the Chairman and Director-General of Medical Services Department, Director-General of Medical Sciences Department, Director General of Communicable Disease Control Department, Secretary-General of the Food and Drug Administration office, Director-General of Local Administration Department, Director General of The Royal Thai police Department, Director-General of Welfare and Labor Protection Department, Director-General of Industrial Work Department. Director-General of Agriculture Department, Secretary-General of the National Environment Board, Permanent Secretary for the Bangkok Metropolitan Administration, and not exceeding five qualified persons appointed by the Minister from amone persons knowledgeable or experienced in public health as members, and Director-General of Health Department as member and secretary.

SECTION 10. The Committee shall have powers and duties as follows

(1) to offer opinion to the Minister on ;precription of policy, work plan, and measure on public health and on any matter with which the Minister entrusts;

(2) to make study and analysis and give opinion to the Minister on improvement of laws, rules, regulations, and orders on public health ;

(3) to provide to the Minister in the issuance of ministerial regulations and to local government on issuance of local provisions;

(4) to provide advice to local officials on execution of this Act ;

(5) to determine projects and coordinate work between government agencies and local governments concerned for the execution of this Act ;

(6) to control and oversee the duty performance of government agencies vested with powers and duties

to execute laws on public health and report to the Minister;

(7) to perform any other task prescribed by the law as authority and duty of the Committee.

SECTION 11. In the event it appears to the Committee that the government agency or local official in the jurisdiction of any locality failed to execute his powers and duties under this Act without a plausible reason, the Committee shall notify the person vested with powers and duties to control and oversee the duty performance of local governments or local officials under the law thereon to order the local government or local official to perform the duty or correct the performance of duty within a period deemed appropriate.

SECTION 12. Members who are qualified persons shall have a term of office of two years. Members who vacated office may be re-elected.

SECTION 13. In addition to vacating office upon expiration of term of office pursuant to Section 12, members who are qualified persons shall vacate office upon

(1) death ;

(2) resignation ;

(3) dismissal by the Minister;

(4) becoming bankrupt ;

(5) becoming incompetent or quasi-incompetent ;

(6) being sentenced to imprisonment by a final judgment, except a penalty for an offense committee in negligence of misdemeanor.

SECTION 14. In the event of an appointment of a qualified member during the term of office of the qualified members already appointed, be an appointment of an additional member or a replacement member, the newly appointed member shall hold office for a period equal to the remainder of term of office of the qualified members already appointed or of the qualified member he replaced, as the case may be.

SECTION 15. In a meeting of the Committee, there shall be members present in a number not less than on half of the total number of members to form a quorum. If the Chairman is absent, the members present shall elect a member among themselves to preside over the meeting.

A decision of the meeting shall be by a majority of votes. One member shall have one vote. When votes are tied, the meeting Chairman shall give the casting vote.

SECTION 16. The Committee shall have powers to appoint subcommittees to consider matter or carry out task with which it is entrusted by the Committee, and Section 15, shall apply to the meeting of the subcommittee mutatis mutandis,

SECTION 17. In performing duty under this Act, the Committee shall have powers to issue a notice summoning any person to testity to submit related documents or evidence or any material for consideration. In the event it deems appropriate, the Committee may empower any of the subcommittees pursuant to Section 16 to issue said order on its behalf for consideration of matters under the powers and duties of the subcommittee.

CHAPTER 3
Disposal of Sewage and Solid Waste

SECTION 18. Disposal of sewage and solid' waste in the area of any local government shall be the power and duty of such local government.

With reasonable cause, the local government may entrust any person with the task pursuant to paragraph one on its behalf under the- control and supervision of the local government or may permit any person to operate the disposal of sewage or solid waste under Section 19.

SECTION 19. Any person is forbidden to operate the business of collecting, transporting, or disposing of sewage or solid waste as a business or for payment of service charges, unless he has obtained a license from the local official.

SECTION 20. For the purpose of maintenance of cleanliness and establishment of orderliness in collecting, transporting, and disposing of sewage or solid waste the local government shall have powers to issue local provisions as follows

(1) forbidding the discharging, emptying, leaving, or causing to exist in a public place or way of sewage or solid waste, except In the place provided by the local government for such purpose ;

(2) prescribing that there be receptacles for sewage or solid waste available along public places or ways and private places;

(3) prescribing means of collecting, transporting disposing of sewage or solid waste or that owner or occupant of any building or place be required to practice correctly according to the hygiene and to the condition and nature of use of such building or place ;

(4) prescribing rate of fees for services provide by the local government on collection and

transportation of sewage of solid waste not exceeding that prescribed in the ministerial regulation ;

(5) prescribing rule, procedure, and conditions on collecting, transporting, and disposing of sewage or solid waste, for observance by persons obtaining a license pursuant to Section 19, and prescribing a rate of maximum charges collectable by the persons obtaining a license pursuant to Section according to the nature of services provided.

(6) prescribing any other requirements necessary for hygienic practice.

CHAPTER 4
Sanitary Building

SECTION 21. When it appears to the local official that any building or part thereof or any addition thereto is dilapidated or left in a mess to and extent that may endanger health of the inhabiters, or does not conform to sanitary conditions rendering it fit for human habitation, the local official shall have powers to issue a written order to the owner or occupant there of requiring him to repair, alter, or demolish the building or the addition thereto in whole or in part, or to take other action necessary to prevent it from endangering health or to conditions within a reasonable period of time as prescribed.

SECTION 22. When it appears to the: local official that any building is excessively stored with merchandise, furniture, or supplies or those articles are so excessively piled up as to provide holes for vermin or likely to endanger health of the inhabiters, or not in conformity to sanitary conditions rendering it fit human habitation, the local official shall have powers to Issue a written order to the owner or occupant of the building requiring him to remove the merchandise, furniture, or supplies out of such Building, or to rearrange them so that they may not endanger health or to be in conformit with sanitary conditions, or to eliminate the animals that are carriers of disease, a reasonable period of time as prescribed.

SECTION 23. In the event the local official hand issued an order to the owner or occupant of a building wider Section 21 or Section 22 and such person failed to comply with the order within the prescribed period,the local official may enter to carry out the task at the expense of the owner or occupant.

SECTION 24. For the purpose of controlling any building from being so over-inhabited as to likely to endanger the health of the occupants thereof, the Minister shall, by and with advice of the Committee, have the power to make an announcement in the Royal Government Gazette prescribing a number of persons per number of area of a building to be deemed overcrowded, however, taking into consideration the development level, population, and commodities of each locality.

Upon announcement by the Minister under paragraph one, the owner or occupant of the building thereunder is forbidden to permit or have his building inhabited by a number of persons exceeding that prescribed .by the Minister.

CHAPTER 5
Sources of Nuisance

SECTION 25. In the event of an occurrence that may cause annoyance to residents in the neighboring area or expose persons to the following, it shall be a sourece of nuisance:

(1) a water resource, gutter, shower room, latrine, or dung or ash pit, or any other place, which is situated at an unsuitable spot, dirty, or accumulated or plied up with any waste which causes foul odor or toxic particle or becomes or is likely to become a breeding place for carreies of disease or causes impairment or may be harmful to health;

(2) a raising of animals in a place or by any method or in too great a number that causes impairment or may be harmful to health ;

(3) any building which is a dwelling of men or animals, factory, or business establishment without air ventilation, water drainage, disposal of sewage, or control of toxic substance, or with such but without adequate control to prevent foul odor or toxic substance, and thereby cuasing impairment or likely being harmful to health ;

(4) any action which causes odor, light, ray noise, heat, toxic matter, vibration, dust; powder, soot, ash, or any other. to the extent that causes impairment or may be harmful to health

(5) any other source prescribed by the Minister and promulgated in the Royal Government Gazette.

SECTION 26. The local, official shall have powers to forbid any, person to cause a nuisance in a public place or way or private place and also to abate nuisance, and to look after, improve, and maintain roads, land routes, watercourses, gutters, trenchos, canals, and other places to be free from sources of nuisance. In this connection, the local official shall have powers to issue written order to abate, eliminate, and control sources of nuisance.

SECTION 27. In the event a nuisance occurs or may occur in a public place or way, the local official shall have powers to issue a written order to the person who is the cause or is involved in the occurrence or

possible occurrence of such nuisance requiring him to abate or prevent the nuisance within a reasonable period of time as specified in the order and, if he deems it expedient to prescribe the method of the abatement or prevention of such nuisance or to prescribe the method of the prevention of future nuisances, he shall specify such method in the order.

In the event it appears to the local official that an order of the local official pursuant to paragraph one was not complied with and the nuisance that occurred may cause serious harm to health, the local official shall abate such nuisance and may take measures necessary to prevent recurrence of such nuisance at the expense of the person who was the cause or involved in the occurrence or possible occurrence of the nuisance.

SECTION 28. In the event a nuisance occurs in a private place the local official shall have powers to issue a written order to the owner or occupant of such place requiring him to abate the nuisance within a reasonable period of time as specified in the order and, if he deems it expedient to prescribe the method of abatement of such nuisance or the method of prevention of future nuisances, to specify such method in the order.

In the event of noncompliance with an order of the local official pursuant to paragraph one, the local official shall have powers to enter to abate such nuisance and my take measures necessary to prevent future nuisances ; and, if the nuisance was caused by the action or omission to act or consent of the owner or occupant of such place, said owner or occupant of the place must bear the expenses incurred therein.

In the event it appears to the local official that the nuisance occurring in a private place may cause a serious harm to health or an impact on the living conditions suitable to the livelihood of the population, the local official may issue a written order forbidding the owner or occupant to use or permit any person to use such place in whole or in part until the local official is satisfied that the nuisance has been abated.

CHAPTER 6

Control of Animal Raising or Grazing

SECTION 29. For the purpose of maintaining the living conditions suitable to the livelihood of the population in the locality or to prevent danger from animal diseases, the local government shall have powers to issue local provisions determining an area covering the whole or any part of the locality under the jurisdiction of such local government, an area of control of animal raising or grazing.

In issuing the local provisions of local government pursuant to paragraph one, the local government may determine an area forbidding raising or grazing animals of certain kind or type or in a number exceeding that prescribed; or an area permitting raising or grazing animals of certain kind or type under certain measure.

SECTION 30. In the event the local official finds animals left in a public place or way in violation of Section 29 and of an unknown ownership, the local official shall have powers to detain said animals for at least thirty days. Upon expiration of the period, if ,no person came forward to claim the animals, such animals shall become property of the local government. But if the detention of the animals may cause harm to such animals -or other animals or cost 'too high, the local official may arrange the sale or auction of such animals as deemed appropriate for the case before said period expires. The proceeds from the sale or auction, after deduction of expenses incurred in the sale and auction of or in feeding the animals shall be retained in lieu of the animals.

In the event the sale or auction of the animals pursuant to paragraph one has not taken place and the owner of the animals came to claim the animals within the period prescribed under paragraph one, the owner of the animals must reimburse the local government for expenses actually incurred in feeding the animals.

In the event the animals found by the local official under paragraph one are carrying a contagious disease which may be dangerous to the population, the local official shall have powers to destroy or treat them in any way deemed appropriate.

CHAPTER 7

Business Detrimental to Health

SECTION 31. The Minister shall, with advice of the Committee, have powers to promulgate in the Royal Government Gazette prescribing any business being detrimental to health.

SECTION 32. For the purpose of overseeing the operation of businesses promulgated under Section 31, the local government shall have powers to issue local provisions of local government as follows

(1) prescribing category of certain or every business under Section 31 being a business requiring control within such locality ;

(2) prescribing general rules and conditions for observance by operate of businesses pursuant to (1) in respect of care of condition or sanitary quality of the place used for business operation and preventive

measures against harm to health.
SECTION 33. Upon the lapse of a sixty days' period from the date on which the local provisions, pursuant to Section 32 (1) because effective, any person is forbidden to operate business of categories specified by the local provisions of the local government to be those requiring control pursant to Section 32 (1) in a commercial nature, unless a license is obtained from the local official under Section 56.

In issuing a license under paragraph one. the local official may prescribe conditions, especially requiring the license to prevent harm to the health of the public, in addition to the general conditions in the local provisions of the locality pursuant to Section 32 (2)

The license pursuant to paragraph one shall be valid for business of a single category and for a single place.

CHAPTER1 **8**

Marketplace, Place Where Meals Are Sold, and Place Where Foodstuff is Stored

SECTION 34. Any person is forbidden to establish a marketplace, unless a license is obtained from the local official under Section 56.

Alteration, expansion, or reduction of the place or area used as the marketplace after the local official has issued the license to establish a marketplace may be made only with a written permission of the local official under Section 56.

Provisions in this Section shall not apply to the ministry, bureau, department, local government, or state organization that has established a marketplace according to its authority and duty, but in operation of the marketplace activities it must, like the license, comply with other provisions of this Act, and the local official shall have powers to prescribe conditions in writing for observance by any particular licensee pursuant to paragraph one.
SECTION 35. For the purpose of supervision of the marketplace the local government shall have powers to issue local provisions as follows

(1) to prescribe location, area, layout, and rule on construction and sanitation ;

(2) to prescribe rule on arrangements of the place and merchandise and other matters pertaining to marketplace operation ;

(3) to prescribe opening and closing times;

(4) to prescribe rule and procedure for observance by the licensee In respect of maintenance of clean Illness and orderliness within the marketplace in conformity with proper hygienic conditions, availability of area for gathering or disposing of sewage or solid waste, discharge of water waste, air ventilation, prevention of nuisances, and prevention of the spreading of contagious diseases.
SECTION 36. Any person who sells merchandise or assists in selling merchandise In the marketplace must comply with (he, rules prescribed in the local provisions pursuant to Section 37.
SECTION 37. For the purpose of supervision of merchandise selling in the marketplace ,the local government shall have powers to issue local provisions prescribing rule and procedure for observance by persons sealing merchandise and persons assisting in selling merchandise in the marketplace in respect of maintenance of cleanliness at the place of sale, personal hygiene, and hygienic conditions in the process of distribution; preparation, or storing of food or other goods, including maintenance of cleanliness of receptacles, water, and utensils.
SECTION 38. Any person who wishes to set up place where meals are sold or a place where foodstuff is stored in any building or space with an area exceeding two hundred square-meters and which is not the sale of merchandise in marketplace must obtain a license from the local official under Section 56, If said place has an area not exceeding two hundred square-meters, he must notify the local official for a certificate of notification pursuant to Section 48 before setting up thereof.
SECTION 39. Persons who set up a place where meals are sold or a place where foodstuff is stored, who have obtained a license pursuant to Section 56 or a certificate of notification pursuant to Section 48, and persons who distribute, prepare, or stored food in a place where meals are sold or a place where foodstuff is stored pursuant to Section 38 must comply with the rule prescribed in the local provisions pursuant to Section 40 or the conditions prescribed in the license or certificate of notification.
SECTION 40. For the purpose of control or supervision of places where meals are sold and places where foodstuff is stored, with a license or certificate of notification, the local government shall have powers to issue local provisions as follows

(1) prescribing category of places where meals are sold or places where foodstuff is stored, according to type of food or characteristic of the business establishment, or methond of distribution ;

(2) prescribing rule on establishment, use, and care of the place and hygienic conditions of the area where food is sold, served, prepared, or stored ;

(3) prescribing rule on prevention of nuisances and prevention of contagious disease ;

(4) prescribing food distribution time ;
(5) prescribing criteria on personal hygienic conditions of persons preparing and serving food ;
(6) prescribing criteria on hygienic conditions of food and process of food distribution, preparation, and storage ;
(7) prescribing criteria on hygienic conditions receptacles, equipment, water, and other utensils.

CHAPTER 9
Distribution of Merchandise in Public Places or Ways

SECTION 41. The local official has the duty to control and maintain public places or ways for common use by the general public.

Any person is forbidden to distribute merchandise in public places or ways, whether by placing merchandise at a spot by peddling, unless a license is obtained from the local official under Section 56.

In issuing a license pursuant to paragraph two, the local official shall specify kinds or types of merchandise, method of merchandise distribution, and, place for merchandise offering in the case the merchandise is displayed at a regular spot, and may also prescribe any condition as deemed appropriate in the license.

A change of the kind or type of merchandise, method of merchandise distribution, or place of merchandise offering from that specified in the license may be made only when the licensee has duly notified the local official thereof and the. local official has recorded said change in the license.

SECTION 42. The local official shall, with approval of the traffic official, have powers to make announcements as follows

(1) designating an area of the public place or way or any part thereof the area forbidding merchandise distribution or purchase ;

(2) designating an area of the public place or way or any part thereof the area forbidding distribution of merchandise of certain kind or type or the area forbidding distribution of merchandise during the prescribed time or the area forbidding distribution of merchandise by any method, or prescribing rule, procedure, and conditions an merchandise distribution in such area.

In making an announcement pursuant to (1) or (2), the local official shall post it up in a conspicuous place at the official of the local government and at the area to be designated the area under (1) or (2), as the case may be, and must fix the date on which the announcement will come into force, not to be later than fifteen days from the date of the announcement.

SECTION 43. For the benefit of the public and for the purpose of control of merchandise distribution in public places or ways; the local government shall have powers to issue local provisions as follows.

(1) prescribing criteria on person hygienic conditions of the contributors of merchandise or assistants in distributing merchandies ;

(2) prescribing criteria on hygienic conditions in the use of processes to distribute, prepare, or store food or other goods; including maintenance of cleanliness of receptacles, water, and utensils;

(3) prescribing rules on arrangement and peddling of merchandise in public places or ways;

(4) prescribing time for merchandise distribution ;

(5) prescribing other measures necessary for maintaining cleanliness and preventing harm to health, including prevention of nuisances and contagious diseases.

CHAPTER 10
Powers and Duties of Local Official and Public Health Official

SECTION 44. To execute this Act, the local official and public health official shall have powers as follows:

(1) to summon any person to testify or give factor or submit any document for examination or consideration ;

(2) to enter any building or place between dawn and dusk or during work hours to inspect or control for compliance with local provisions or this Act and, in this connection, to make inquiry or request production of the certificate of notification or related evidence by the owner or occupant of such building or place;

(3) to require persons obtaining a license or certificate of notification to comply with the conditions in the license or certificate of notification or with the. local provisions or with this Act ;

(4) to confiscate or attach any thing that may cause harm to the health of the population as evidence in legal action or for destruction if necessary;

(5) to collect or take merchandise or any thing suspected to be inhygienic or to cause a nuisance from any building or place in a reasonable quantity as samples for examination as necessary at no cost.

The local official shall have powers to appoint a government servant or local official to perform any or every of the duties pursuant to paragraph one in the jurisdiction of such local government.

In performing duty, the local official or public health official or the appointed person must produce his indentity card in the form prescribed in the ministerial regulation to the person concerned while performing duty and the person concerned shall provide reasonable convenience.
SECTION 45. In the event it appears that an operator of any business as specified in this Act acted incorrectly in accordance with this Act ; the ministerial regulation, local provisions, or notification issued under this Act or the order of the local official given on such business, the local official shall have powers to order the operator of such business to make improvement or correction. If the operator of the business failed to make correction 'or the business operation will cause or there is reason to believe that there will occurs serious harm to the health of the population, the local official may order such person to temporarily suspend the operation of such business promptly until the local official is satisfied that no harm exists.

The order of the local official pursuant to paragraph one shall prescribe a reasonable period for compliance but not to be less than seven days, unless the order requires a prompt .suspension and a written notice is duly served to the business operator. In the event the business operator could not be found or he refused to accept said order, the order shall be sent by registered mail, acknowledgement return, or posce up conspicuously at the domicile or office of the business operator and it shall be deemed to have been received by such person on the date of its arrival or posting up, as the case may be.
SECTION 46. In the event the public health official detects improper occurence or any act having been committed in violation of this Act or the local provisions, he shall notify the local official thereof for action according to his powers and duties without delay.

In the event the public health official is of the opinion that the occurrence pursuant to paragraph one will have an impact on the living condition suitable for livelihood of the population or will be seriously harmful to the health of the people as a whole and that the occurrent must be urgently remedied, he shall have powers to order the person to effect correction or cessation, or he may take any action to remedy or cease the occurrence as necessary and then notify the local official thereof for information.
SECTION 47. In performing duty under this Act, the local official, public health -official , and person appointed by the local official under section 44 shall be competent officials under the Criminal Code and, for the purpose of arresting or suppressing persons committing offenses under this Act, the local official and person appointed by the local official shall be administration or police officials under the Criminal Procedure Code.

CHAPTER 11
Certificate of Notification

SECTION 48. A notification to the local official for action pursuant to Section 38 and a certificate of notification shall in the form prescribed in the local provisions.

When the local official is notified, he shall issue a receipt therefor to the notifier temporary use as evidence in operating the business as notified while a certificate of notification has not been issued by the local official.

The local official shall examine a notification for correctness according to the form prescribed in the local provisions pursuant to paragraph one. Finding the notification in order, the local official shall issue a certificate of notification to the notifier within seven workdays from the date of receipt of the notification.

In the receipt for notification or certificate of notification, the local official may prescribe conditions to the notifier or obtain .of certificate of notification, case by case.

In case of an incorrect or incomplete notification, the local official shall notify the notifier accordingly within seven workdays from the date of receipt of the notification. If the notifier failed to make correction within seven workdays from the date of receipt of notification by the local official, the local official shall-have powe to order the notification of the notifier invalid. But if the notifier made correction within the prescribed period, the local official shall issue a certificate of notification to the notifier within seven workdays from the date of the notification which has correct details according to the form prescribed in the local provisions pursuant to paragraph one.
SECTION 49. The obtainer of a certificate of notification must display the certificate of notification openly and conspicuously at the business establishment throughout the time of business operation.
SECTION 50. In the event a certificate of notification Is lost. destroyed, or damaged in essence, the obtainer thereof shall apply for a substitute therefor within fifteen days from the date of knowledge of loss, destruction, or damage.

Application for and issuance of a substitute for certificate of notification shall be in accordance with the rule and procedure in the local provisions.
SECTION 51. A notifier pursuant to Section 48, who wishes to windup the business or assign the business to other person, shall also notify the local official for information.
SECTION 52. In case any person operates a business specified in this Act without notifying the local

official under Section 48 and used to be punished once with a penalty under this Act for operating business without notifying the local official but still continues to operate the business without notifying the local official, the local official shall have powers to order such person to suspend the business operation until he will have notified the local official under Section 48. If he still violates the provision, the local official shall have powers to order a suspension of the business operation for the prescribed period which must not exceed two years.

SECTION 53. A notification of the local official pursuant to Section 48 and an order of the local official pursuant to Section 52 shall be in writing for information of the notifier or business operator. In the event such person could not be found or refused to accept the notice, it shall be sent by a registered mail, acknowledgement return, or posted up openly and conspicuously at the domicile or office such person and it shall be deemed to have been received at the time arrived or was posted up, as the case may be.

CHAPTER 12
License

SECTION 54. In case this Act provides that the operation of any business or performance of any act requires a license from the local official, the local government shall have powers to issue local provisions prescribing rule, procedure, and conditions for application for and issuance of a license or such matter.

SECTION 55. All licenses issued under this Act are valid for on year from the date of issuance and shall be used only in the jurisdiction of the issuing local government.

An application for renewal of a license must be submitted before the license expires. Upon submission of the application and payment of fee, business operation may continue until the local official issues an order not to renew the license.

Rule, procedure, and conditions for application for renewal of license and permission to renew license shall be as prescribed in the local provisions.

SECTION 56. Upon receipt of an application for a license or an application for license renewal, the local official shall examine the application for correctness and completeness. if said application is not correct or complete according to the rule, procedure, or conditions prescribed in the local provisions, the local official shall compile all incorrectness and incompleteness and notify the applicant to make correction thereof at the same time and, In case it is necessary to return the application to the applicant, shall return the application together with the compilation of incorrectness and incompleteness within fifteen days from the date of receipt of the application.

The local official must issue a license or a notice of order of nonpermission together with reasons for nonpermission to the applicant within thirty days from the date of receipt of the application which is correct and complete as prescribed in the local provisions.

In the event the local official cannot possibly issue a license or a notice of order of nonpermission within the period pursuant to paragraph two, the period may be extended not more than twice, each time for not more than fifteen days, but a notice must be Issued to Inform the applicant of time extension and reason every time before expiration of the period pursuant to paragraph two or the extended period, as the case may be.

SECTION 57. Obtainers of a license under this Act must display the license openly and conspicuously at the business establishment throughout the time of business operation

SECTION 58. In the event a license is lost, destroyed, or damaged in essence, the obtainer of the license shall submit an application for a substitute therefor within fifteen days from the date of knowledge of loss, destruction, or damage.

Application for and Issuance of a substitute for license shall be in accordance with the rule, procedure, and conditions prescribed in the local provisions.

SECTION 59. In the event it appears that the obtainer of a license to operate any business failed to comply or Incorrect complied with provisions of this Act or the ministerial regulation or with the local provisions issued under this Act or with conditions specified in the license in respect of operation of the business under the license, the local official shall have powers to order suspension of the license for a reasonable period but not exceeding fifteen days.

SECTION 60. The local official has powers to order revocation of the license when it appears that the obtainer of the license

(1) has been given order of license suspension twice and more and there is cause for another license suspension ;

(2) is sentenced by a final judgment for an offense under this Act ;

(3) failed to comply or incorrectly complied with provisions of this Act or the ministerial regulation or with the local provisions issued under this Act or with condition specified in the license in respect of operation of the business under the license and such noncompliance or incorrect compliance caused

serious harm to the health of the population or had an impact on the living conditions suitable for livelihood of the population.
SECTION 61. An order of license suspension or license revocation shall be made in writing for the information of the license obtainer. In the event the license obtainer could not be found or refused to accept the order, it shall be sent be sent by a registered mail, acknowledgement return, or posted up conspicuously at the domicile of office of the license obtainer and it shall be deemed to have been received on the date it arrived or was posted up, as the case may be.
SECTION 62. A person whose license is revoked may not apply for a license to operate the business for which the license was revoked until the expiration of one year's period from the date of the license revocation.

CHAPTER 13
Fee and Fine

SECTION 63. The local government shall have powers to issue focal provisions prescribing fees in accordance with the criteria, procedure, and conditions and not exceeding the rate prescribed in the ministerial regulation.
SECTION 64. All fees and fines under this Act shall be a revenue of the local government.
SECTION 65. In case the local provisions prescribe fees for the operation of businesses which must be notified to the local official before operation or which require a license under this Act, the notifier or license obtainer shall have the duty to pay the fees at the rate and interval prescribed in the local provisions throughout the operation of such business. If the fees were not paid within the prescribed period, a fine shall be paid at a rate of twenty percent of the outstanding amount of fees, unless the notifier or license obtainer has notified the winding up of the business before the date due for the next payment of fees, as prescribed in the local provision.

In the event the person who has the duty to pay fees under paragraph one has been in arrears in paying fees for more than two periods, the local official shall have powers to order such person to suspend his business operation until the fees and fines will have been paid in full.

CHAPTER 14
Appeal

SECTION 66. In the event the local official issued on order under Section 21, Section 22, Section 27 paragraph one, Section 28 paragraph one or paragraph three, Section 45, Section 48 paragraph five, Section 52, or Section 65 paragraph two, or Issued an order not to issue a license or not permit renewal of the license or to revoke the license under this Act, or in the event the public health official issued an order under Section 46 paragraph two, if the order receiver was not satisfied with said order, such person has rights to appeal to the Minister within thirty days from the date of knowledge of such order.

An appeal pursuant to paragraph one shall not be a cause for suspension of the order enforcement, unless the Minister deems it appropriate to have the order enforcement temporarily suspended.
SECTION 67. Consideration of an appeal pursuant to Section 66 shall be made by the Minister without delay.

Decision of the Minister shall be final.

CHAPTER 15
Penalties

SECTION 68. Any person who violated the ministerial regulation issued under Section 6 is liable to a fine not exceeding ten thousand baht.
SECTION 69. Any person who failed to comply with an order of the Director-General of Health issued under Section 8 paragraph one without plausible reason or excuse, or obstructed the duty performance of the public health official under Section 8 paragraph two or of the provincial public health officer under Section 8 paragraph three, is liable to an imprisonment not exceeding two months or a fine not exceeding five thousand or both.
SECTION 70. Any person who failed to comply with on order of the Committee or subcommittee issued under Section 17 without plausible reason or excuse in liable to an Imprisonment not exceeding one month or a fine not exceeding two thousand baht or both.
SECTION 71. Any person who violated Section 19, Section 33 paragraph one, or Section 34 is liable to an imprisonment not exceeding six months or a fine not-exceeding ten thousand baht or both.
SECTION 72. Any person who set up a place where meals are sold or a place where foodstuff Is stored with an area exceeding two hundred square-meters without a license is liable to an imprisonment not

exceeding six months or a fine not exceeding ten thousand baht.

Any person who set up a place where meals are sold or a place where foodstuff Is stored with an area not exceeding two hundred square meters without a certificate of notification is liable to an imprisonment not exceeding three months or a fine not exceeding five thousand baht.

SECTION 73. Any person who violated the local provisions issue under Section 20 (5), Section 32 (2), Section 35 (1) or (4), or Section 40 (2) or (3) Is liable to an Imprisonment not exceeding six months or a fine not exceeding ten thousand baht or both.

Any person who violated the local provisions issued under provisions of this Act except those In paragraph one and In Section 37 or Section 43 Is liable to a fine not exceeding five thousand baht.

SECTION 74. Any person who failed to comply with an order of the local official issued under Section 21, Section 22, Section 27 paragraph one, or Section 28 paragraph one or paragraph three without plausible reason or excuse, or obstructed the duty performance of the local official under Section 23, Section 27 paragraph two, or Section 28 paragraph two, is liable to an imprisonment not exceeding one month or a fine not exceeding two thousand baht or both.

SECTION 75. Any owner or occupant of a building violated Section 24 paragraph two is liable to a fine not exceeding one thousand baht and a daily fine not exceeding five hundred baht throughout the period of violation.

SECTION 76. Any license obtainer who failed to comply with the conditions precribed by the local official in the license under Section 33 paragraph two or Section 41 paragraph three is liable to a fine not exceeding two thousand baht.

SECTION 77. Any person who violated Section 41 paragraph two or the announcement of the local official pursuant to Section 42 (1) is liable to a fine not exceeding two thousand baht.

SECTION 78. Any person who failed to comply with Section 36 or violated the announcement of the local official pursuant to Section 42 (2) or the local provisions issued under Section 43 is liable to a fine not exceeding one thousand baht.

SECTION 79. Any person who failed to comply with a summons, or refused to give facts or submit documents or evidence, or obstruct or provided no convenience to the duty performance of the local official or public health official or person appointed by the local official under Section 44, is liable to an imprisonment not exceeding one month or a fine not exceeding two thousand baht or both.

SECTION 80. Any business operator who operated the business while under suspension by an order of the local official issued under Section 45, Section 52, or Section 65 paragraph two without plausible reason or excuse is liable to an imprisonment not exceeding six months or a fine not exceeding ten thousand baht or both and a daily fine not exceeding five thousand baht throughout the period of noncompliance.

SECTION 81. Any person who failed to comply with an order of the public health official issued under Section 46 paragraph two with-out plausible reason or excuse or obstructed the duty performance of the public health official is liable to an imprisonment not exceeding five thousand baht or both.

SECTION 82. Any person who failed to comply with Section 49 or Section 50 is liable to a fine not exceeding five hundred baht.

SECTION 83. Any license obtainer who violated Section 57 or Section 58 is liable to a fine not exceeding five hundred baht.

SECTION 84. Any license obtainer who operated the business during the period of the license suspension is liable to an imprisonment not exceeding six months or a fine not exceeding ten thousand baht or both and a daily fine not exceeding five thousand baht throughout the period of violation.

SECTION 85. There shall be a fine determination committee

(1) in Bangkok Metropolitan area, comprising a representative of Bangkok Metropolitan Administration, Office of the Chief Public Prosecutor, and the Royal Thai Police Department;

(2) in other provincial area, comprising the provincial governor, provincial public prosecutor, and Chief of the provincial police headquarter.

For all offenses under this Act, if it is deemed that the accused should not be subjected to a sentence to imprisonment or should not be tried, the committee shall determine a fine. For an offense for which the penalty is a fine alone or an imprisonment not exceeding one month or a fine not exceeding two thousand baht or both, the local official or person appointed by the local official shall have powers to determine the fine.

Upon payment of the fine as determined within thirty days from the date of determination, the case shall be deemed settled under the Criminal Procedure Code.

If the accused refused to pay the fine as determined or agreed there but failed to pay the fine within said period, legal action shall be- taken.

CHAPTER 16
Transitory Provisions

SECTION 86. An obtainer of a license to operate any business under the law on public health, whose license was revoked before the date on which this Act comes into force and such business has the same nature as that which requires a license or a certificate of notification under this Act, such person may continue to operate such business as if he were an obtainer of a license or certificate of notification under this Act, but upon expiry of said license and such person wishes to operate the business on, he must apply for a license or submit a notification under this Act before operation.

SECTION 87. A person who operates any business, which requires no certificate of notification under the law on public health repealed by this Act but is a business requiring a certificate of notification under this Act, and is not a person already obtaining a license pursuant to Section 86, may continue to operate the business but must notify the local official within ninety days from the date this Act came into force.

SECTION 88. Any person who operates any business, which requires a license under the law on public health repealed by this Act but requires a license under this Act, may continue to operate the business but must apply for a license under this Act within ninety days from the date this Act came into force. Upon submission of the application, he may operate the business on until an order is issued not to issue a license to operate the business under this Act.

SECTION 89. Subject to Section 31 or Section 32, all. business designated undersirable or possibly harmful to health under Section 7 of the Public Health Act B.E. 2484 and hairdressing under Section 31 of the public Health Act B.E.2484 shall be deemed businesses harmful to health.

SECTION 90. All ministerial regulations, notifications, ordinances, by-laws, or orders of the local official or public health official issued by virtue of the law on public health repealed by this Act shall continue to be in force insofar as they are not inconsistent with or contrary to the provisions of this Act, however, until there exist ministerial regulations, notifications. local provisions, or orders of the local official or public health official issued under this Act.

Countersigned by
Anan Panyarachun
Prime Minister

ANNEX VI FACTORY ACT 1992

Thailand Factory Act of 1992

FACTORY ACT B.E. 2535
(Unofficial English Translation)

BHUMIBOL ADULYADEJ REX.
Given on the 2nd day of April, B.E. 2535;
Being the 47th year of the Present Reign.

His Majesty King Bhumibol Adulyadej has been graciously pleased to proclaim that :
Whereas it is expedient to revise the law on factory.

BE IT THEREFORE ENACTED BY THE KING, by and with the advice and consent of the National Legislative Assembly acting as the Parliament, as follows:

Section 1 This Act shall be called the "Factory Act., B.E. 2535".
Section 2 This Act shall come into force as from the ninety days following the date of its publication in the Government Gazette.
Section 3 The following Acts shall be repealed.
(1) The Factory Act, B.E. 2512
(2) The Factory Act (No. 2), B.E. 2518
(3) The Factory Act (No. 3), B.E. 2522
Section 4 The Act shall not apply to the Government factory run by the Government for the purpose of national security and safety provided that the engagement of such factory business shall be guided by the criteria and procedures relating to the engagement of a factory business under this Act.
Section 5 In this Act
"Factory" means a building, place, or vehicle which uses a machine from five horse powers or an equivalent thereof or more or which employs seven workers or more with or without any machine for manufacturing, producing, assembling, filling, repairing, maintaining, testing, improving, altering, transporting, keeping, or destroying anything in accordance with the type or kind of factory as provided for in a ministerial rule.
"Establishing a Factory" means a construction of the buildings for the installation of machines for engaging in a factory business or installation of the machines for engaging in a factory business in the buildings, places, or vehicles to be engaged in such business.
"Machine" means a component of several pieces for generating energy, changing or altering energy or transmitting energy by the force of water, steam, wind, gas, electricity, or any other energy or energies combined and also includes fly-wheel equipment, pulleys, belts, axles, gears, or other things which work reciprocally.
"Worker" means a person who works in a factory but excluding a person working in an administrative staff.
"Grantor" means the Permanent Secretary of the Ministry or a person appropriately assigned by the Permanent Secretary of the Ministry.
"Permit" means a permit for the engagement in a factory business.
"Authority" means a person appointed by the Minister for the execution of this Act.
"Permanent Secretary" means the Permanent Secretary of the Ministry of Industry.
"Engagement in a factory business" means manufacturing, producing, assembling, filling, repairing, maintaining, testing, modifying, altering, transporting, keeping or destroying anything in accordance with the nature of the business of the factory but excludes the operation test of the machines.
"Minister" means the Minister who takes charge of this Act.
Section 6 The Minister of Industry shall take charge of the execution of this Act and shall have the power to appoint the authorities and to prescribe the ministerial rules

fixing the fees of not higher than the rates attached herewith, exempting the fees and adopting other requirements for the execution of this Act.
The ministerial rules and announcements of the Minister prescribed pursuant to this Act, upon publication in the Government Gazette, shall become enforceable.

Chapter 1
Engagement in a Factory Business

Section 7 The Minister shall have the power to prescribe the ministerial rules fixing the factory of any type, kind or size to be the group 1 factory, group 2 factory, or group 3 factory as the case may be by taking into consideration the necessity for the control, prevention of nuisance, prevention of damage, and prevention of danger in accordance with the gravity of impact on the public or environment by classifying as follows.:
(1) Group 1 factory are such factory of the type, kind, and size as capable of engaging in a factory business immediately upon desire of a person engaging in a factory business.
(2) Group 2 factory are such factory of the type, kind, and size as, when engaging in a factory business, must be notified in advance to the Grantor.
(3) Group 3 factory are such factory of the type, kind, and size as to be granted a permit prior to the engagement.
Upon prescription of an announcement of the Minister pursuant to Section 32 (1), the factory designated in such announcement shall also be the group 3 factory.
Section 8 For the purpose of control of the engagement in a factory business, the Minister shall have the power to prescribe the ministerial rules with which any or all groups of factory under Section 7 must comply with respect to the following matters.
(1) To adopt the criteria relating to the location of factory, environment of the factory, nature of the buildings of factory, or interior nature of the factory.
(2) To adopt the nature, type, or kind of machines, equipment or such other things as to be used for the engagement in a factory business.
(3) To adopt the requirements of specialized workers according to the type, kind, or size of factory to perform any duty for such factory.
(4) To adopt the criteria to be followed, process of production and provision of other equipment or tools in order to prevent or stop or mitigate the dangers, injuries, or troubles that may cause to the persons or property in the factory or its vicinity.
(5) To adopt the standards and methods of controlling the discharge of wastes, pollutants or anything that affects the environment as a result of the engagement in a factory business.
(6) To adopt the provision of required documents for the factory, for the purpose of controlling and inspecting the compliances with the laws.
(7) To adopt the required information relating to the engagement in a factory business of which a person engaging in a factory business must inform from time to time or in a specified period.
(8) To adopt any other requirements for the protection of safety in the operations in order to prevent or stop or mitigate the dangers or injuries that may result from the engagement in a factory business.
The ministerial rules under paragraph one may exempt the factory of any type, kind, or size from performing any matter and such ministerial rules may require the matters of technical details or of rapid changes according to the social conditions to be in accordance with the criteria prescribed by the Minister upon publication in the Government Gazette.
Section 9 In case where it is required to inspect the factory or machines for the execution of this Act, an individual may be designated to carry out the inspection and make a

report of the result of the inspection in lieu of the performance of the duties of authorities subject, however, to the regulations prescribed by the Minister upon publication in the Government Gazette.

Section 10 A person engaging in, a factory business of group 1 must comply with the criteria provided for in the ministerial rules prescribed pursuant to Section 8 and the announcements of the Minister prescribed pursuant to the said ministerial rules.

Section 11 A person engaging in a factory business of group 2 must comply with the criteria provided for in the Ministerial rules prescribed pursuant to Section 8 and the announcements of the Minister prescribed pursuant to the said ministerial rules and upon commencing the engagement in a factory business shall notify the authority in advance.

The forms and particulars to be notified and the form of notification receipt shall be in accordance with those provided for in the ministerial rules.

Upon receipt of the notification under paragraph one, the authority shall issue a notification receipt to the notifier as a proof of such notification on the date of receipt of the notification and the notifier shall engage in a factory business as from the date of receipt of such notification receipt.

In case where the authority finds out later that the notification under paragraph one is incorrect or incomplete, the authority shall have the power to order the notifier to correct or complete within seven days as from the date of receipt of such order.

The dissolution of business, the transfer, lease, or hire-purchase of group 2 factory shall be notified in writing by the person engaging in a factory business to the authority within thirty days as from the date of such action.

Section 12 A person engaging in a factory business of group 3 must obtain a permit from the Grantor and must comply with the criteria provided for in the ministerial rules prescribed pursuant to Section 8, the announcement of the Minister prescribed pursuant to the said ministerial rules and the announcements of the Minister prescribed pursuant to Section 32.

No person shall be allowed to establish a factory before obtaining a permit.

The application for a permit and the procedures of consideration and duration of such consideration for the issuance of a permit shall be in accordance with those provided for in the ministerial rules.

In case where the applicant requests for a certificate before a permit is issued, if a preliminary consideration suffices the grant in principle, the Grantor shall issue a certificate upon reservation on the unfinished part according to the criteria prescribed by the Minister upon publication in the Government Gazette.

In issuing a permit, the person having the power to grant a permit shall consider in accordance with the criteria provided for in the ministerial rules prescribed pursuant to Section 8, the announcements of the Minister prescribed pursuant to the said ministerial rules and the announcements of the Minister prescribed pursuant to Section 32. Where no criteria are provided for, it shall be considered by taking into account the safety of the persons or property in the factory or its vicinity or if it must be complied with the announcements of the Minister prescribed pursuant to Section 32, conditions may be provided in a permit to be followed specially by the person engaging in a factory business.

Section 13 A recipient of a permit under Section 12, if wishing to commence the engagement in any part of the factory business, must notify the authority not less than fifteen days prior to the commencing date of engagement in the factory business.

If there shall be any operation test of the machines before commencement of the engagement in a factory business under paragraph one, the recipient of a permit must

also notify the authority of the day, time, and duration of such operation test not less than fifteen days.
The criteria and duration that may be applied to such operation test shall be in accordance with those provided for in the ministerial rules.
Section 14 A permit shall be valid until the last day of the fifth calendar year as from the year of commencement of the engagement in the business except in the case of moving of the factory under Section 27 or of dissolution of the engagement in the factory business, such permit shall be deemed to expire on the date of issuance of a new permit or of dissolution of the factory business.
If it is to appropriate to cease the engagement in the business in a near future, the Grantor, upon approval of the Minister may issue a permit of a shorter period than that provided for in paragraph one. The permit issued in this case may not be renewed.
Section 15 In renewing a permit, a recipient of a permit shall file an application prior to the expiration of a permit. Upon such application, the applicant shall be deemed to be the recipient of a permit until a final order refusing a renewal of a permit is given.
If the result of inspection indicates that the factory and machines are in compliance with Section 8, the announcements of the Minister prescribed pursuant to the said ministerial rules and the announcements of the Minister prescribed pursuant to Section 32 and the conditions provided for in a permit, the Grantor shall renew the permit. In case of incorrectness, the authority shall order a correction within the specified period. Upon such correction, a renewal shall be granted. Failure to make correction within the specified period, the order refusing such renewal of the permit shall be given.
The application for renewal of a permit and grant of such renewal shall be in accordance with the criteria and procedures provided for in the ministerial rules.
A person who fails to file an application for a renewal of the permit within the period under paragraph one, if wishing to continue the engagement in the factory business and having already filed the application for renewal of the permit within the period of sixty days as from the date of expiration of the permit, shall be deemed to file the application within the specified period and the engagement in the factory business during such period shall be deemed as that of the recipient of the permit. However, upon a grant of renewal of the permit, such person shall pay an additional fine of twenty percent of the renewal fee. Upon expiration of the sixty-day period, such person shall proceed as if it were a new application.
Section 16 The order refusing the issuance of a permit or the renewal thereof may be appealed by the applicant for such issuance or renewal to the Minister within thirty days as from the date of receipt of the order. The decision of the Minister shall be final.
Section 17 Any factory for which a person engaging in a business has been granted a permit, if it appears thereafter that such factory uses the machines of lower than five horse powers or employs less than seven workers, such factory shall be deemed to be the factory under this Act until notice of dissolution of the factory business is given or the permit expires.
Section 18 A recipient of a permit may not expand the factory unless permitted by the Grantor.
Section 12, Section 13, and Section 16 shall apply mutatis mutandis to the application for expansion of the factory and the grant thereof including the appeal of the order refusing such expansion.
Expansion of the factory is:
(1) an increase of a number, change or alteration of the machines in order to increase their aggregate powers from fifty percent or more in case where the original machines have their aggregate powers of not more than one hundred horse powers or an equivalent

thereof of not more than one hundred horse powers or to increase from fifty horse powers or more in case the original machines have their aggregate powers of more than one hundred horse powers or an equivalent thereof of more than one hundred horse powers.
(2) an increase or modification of any part of the factory buildings rendering any of their original foundations to carry more weight from five hundred kilograms or more.
A permit as to the expanded part shall be valid for the same period as that of the permit under Section 14.
Section 19 When the recipient of a permit increases a number, changes or alters the machines used for production, machines used for generating power or the energy of the machines to other forms but not amounting to the expansion of the factory or to the increase of the area of the factory building or to the new construction of the factory building for the direct benefits of the business of such factory rendering the area of the factory building to be increased from fifty percent or more in case where the area of the factory building does not exceed two hundred square meters or to be increased from one hundred square meters or more in case where the area of the factory exceeds two hundred square meters, the recipient of the permit shall notify in writing the authority within seven days as from the date of such increase, change or alteration of the machine or increase of the area of factory building or additional construction of the factory building as the case may be and must comply with the criteria and procedures relating to the increase of a number, change or alteration of the machines or increase of the area of the factory building or additional construction of the factory building as provided for in the ministerial rules.
Section 20 The conditions provided for in a permit under Section 12 paragraph five, if the Grantor deems it appropriate to cancel or change or add appropriate conditions to be followed by the recipient of the permit in engaging in a factory business, the Grantor shall so give a written order.
Any recipient of a permit who wants to cancel or change the conditions to be followed in engaging in a factory business shall file an application and explain the reasons to the Grantor. The Grantor shall consider forthwith and give a written order immediately.
If the recipient of the permit does not agree with the opinions of the Grantor, he/she shall appeal to the Minister within the period of thirty days as from the date of receipt of the written order. The decision of the Minister shall be final.
Section 21 In case where the recipients of a permit transfers the factory business, leases or effects a hire-purchase of the factory, or sells the factory, such person shall be deemed to cease the engagement in the factory business as from the date of transfer of the factory business, lease or hire-purchase of the factory or sale of the factory.
The transferee of the factory business, lessee or hire-purchaser of the factory or purchaser of such factory shall apply for a permit within seven days as from the date the engagement of the factory business is deemed to have ceased under paragraph one without paying the permit fee. Upon submission of such application, the engagement in a factory business shall be continued pending the receipt of a permit as if such applicant were the recipient of the permit.
The criteria, procedures, conditions for the acceptance of the transfer and issuance of a permit shall be in accordance with hose provided for in the ministerial rules.
Section 22 In case of death of the recipient of a permit, the heir(s) or administrator(s) shall file an application to the Grantor for the acceptance of the transfer of a permit within ninety days as from the date of death of the recipient of a permit or within a period as extended by the Grantor as he deems necessary. Failure to file an application within the specified period, a permit shall be deemed to expire. If such person(s) wish to

continue the engagement in a factory business, they shall undertake to reapply for a permit.
During the period under paragraph one, the heir(s) or administrator(s) engaging in a factory business shall be deemed as if they were the recipient(s) of a permit.
In case where the recipient of a permit is adjudged an incompetent person, the provisions of the two preceding paragraphs shall apply to the guardian mutatis mutandis.
The criteria, procedures, conditions for the acceptance of the transfer and issuance of a permit shall be in accordance with those provided for in the ministerial rules.
Section 23 The recipient of a permit must present the permit at the open and noticeable place in his/her factory.
Section 24 Upon changing of the name of the factory or of the name of the recipient of a permit, the recipient of a permit shall notify in writing the authority within fifteen days as from the date of such change.
Section 25 In case of loss or destruction of a permit, the recipient of the permit shall apply for a substitute to the authority within fifteen days as from the date of learning of the loss or destruction.
Section 26 The recipient of a permit wishing to move parts of the machines installed in the factory to another place for temporary engagement in a factory business shall file an application for permission to the Grantor together with the chart and other details articulating the reasons for consideration.
If the Grantor deems it appropriate, the Grantor shall grant the move of the machines to engage in a business as requested within tile specified period but not later than one year as from the date of such order. In this respect, the conditions relating to the safety measures may be provided to be followed.
If the recipient of a permit needs to engage in such business beyond the period as permitted under paragraph two, an application for extension of such period shall be filed with the Grantor prior to the expiration of such period. If the Grantor deems it appropriate, the Grantor shall grant the extension of the period for not more than one year.
Section 27 Any recipient of a permit wishing to move the factory to another place shall proceed as establishing a new factory.
Section 28 Any recipient of a permit ceasing the engagement in a factory business shall notify in writing the Grantor within fifteen days as from the date of cessation of the factory business.
If the recipient of a permit wishes to change a group 3 factory to a group 1 factory or group 2 factory as the case may be, the recipient shall notify of the cessation of the factory business under paragraph one and upon continuation of the engagement in the factory business, the recipient shall proceed as provided for in this Act for the engagement in the said groups of factory business.
Section 29 In case where there are the ministerial rules under Section 7 or announcements of the Minster under Section 32(l) rendering a group 1 factory or group 2 factory to be a group 3 factory, if a person engaging in a factory business applies for a permit under Section 12 within the period of thirty days as from the date of coming into force of the ministerial rules, such person shall continue the engagement in the factory business as if he/she were the recipient of the permit and the Grantor shall immediately issue a permit.
Section 30 The Minister shall have the power, upon publication in the Government Gazette, to designate any area to be an industrial zone.
The engagement in a business of group 2 factory or group 3 factory within the industrial zone under paragraph one or the industrial estate established pursuant to the law on

industrial estates shall be exempted from the notification to the authority under Section 11 or permission under Section 12 as the case may be but such engagement in a factory business shall follow the criteria provided for in the ministerial rules prescribed pursuant to Section 8, announcements of the Minister prescribed pursuant to the said ministerial rules, announcements of the Minister prescribed pursuant to Section 32(l) and other provisions relating to the control of engagement in a factory business under this Act provided that it shall be deemed as if he/she were the notifier or the recipient of the permit as the case may be.

Upon designation of any area as the industrial zone or establishment of the industrial estate under the law on industrial estates, the Minister may prescribe a ministerial rule designating a surrounding area of the industrial zone or estate within a specified limit to be an absolutely forbidden zone for factory business or allowing only the engagement in a business of certain type, kind or size of factory.

Section 31 For the purpose of effective public administration and of facilitation to the public, if any engagement in a factory business involves a matter which also requires a permission from the authority under other laws, the authority having the power to execute under this Act and the authority having the power to execute under such laws may adopt the procedures of undertaking for joint consideration.

The undertaking under paragraph one may be effected by joint application or by exemption of the required documents, the particulars or information to be presented, the place of which applications or documents must be submitted and steps of overlapping or similar considerations for permission or which is likely to create unnecessary obstacles for such joint consideration and if it is appropriate, the criteria or procedures will be adopted instead to be followed but such permission must be in accordance with the format provided for in the laws on such matters.

In a joint consideration, the authority having the power to inspect, having the power to consider any part of such permission or having the power to grant permission may delegate his/her power to other authorities involved in the consideration for permission to execute on his/her behalf as is appropriate.

The adoption and delegation under paragraph two, paragraph three, upon publication in the Government Gazette, shall become enforceable.

Chapter 2
Supervision of the Factory

Section 32 For the purposes of economy, conservation of environment, security, safety of the country or of the public, the Minister, upon approval of the Cabinet, shall have the power to adopt, upon publication in the Government Gazette, the following matters:

(1) To adopt a number and sizes of each type or kind of factory to be established or expanded or to refuse the establishment or expansion thereof in any area.

(2) To adopt the kinds, quality, ratio of the raw materials, sources of raw materials and/or factors or kinds of energy to be used or produced in the factory.

(3) To adopt the kinds or quality of the products produced in the factory to be established or expanded.

(4) To adopt the application of the produces of the factory to be established or expanded to certain types of industry or the exportation of all or part of tile produces.

Section 33 If the group 2 factory or group 3 factory cease their operations consecutively for more than one year, a person engaging in the business of group 2 factory or a recipient of' a permit for the business of group 3 factory as the case may be must notify in writing the authority within seven days as from the day following the last date of one year.

If the said person under paragraph one wishing to continue the engagement in the factory business, such person shall notify in writing the authority prior to the commencement of the business and in case of group 3 factory, such person must first obtain a written permission from the authority before engaging in a factory business.
Section 15 paragraph two and Section 16 shall apply mutatis mutandis to the permission of continuation of the engagement in the business of group 3 factory.
Section 34 In case of accident in a factory caused by the factory or a machine thereof regardless of any group of factory, if such accident;
(1) causes death, illness or injury to the persons who after seventy-two hours cannot perform their original duties, the person engaging in a factory business shall notify in writing the authority within three days as from the date of death or expiration of seventy-two hours as the case may be;
(2) causes the operations of the factory to be stopped for more than seven days, the person engaging in the factory business shall notify in writing the authority within ten days as from the date of accident.
When the accident occurs under paragraph one, the authority shall inspect the factory and the machines and consider to proceed under Section 37 or Section 39 as the case may be.
Section 35 For the implementation this Act, the authority shall have the following powers.
1) To enter a factory or building, place or vehicle, suspected to engage in a factory business, during the period from sunrise to sunset or during the working hours of the said place to inspect the condition of the factory, building, place or vehicle, the condition of the machines or any act that may violate the provisions of this Act.
(2) To take the specimens of products suspected of their quality in a reasonable quantity for inspection of their quality together with relevant documents.
(3) To inspect, search, detain, seize or attach the products, containers, book accounts, documents or any relevant articles in case where there is a reasonable ground to suspect that engagement in a business of the factory may cause harms to the persons or property in the factory or its vicinity or an offence under this Act has been committed.
(4) To summon in writing any person to testify or to submit any document or object for consideration.
Section 36 When it appears that any person has committed an offence under this Act or is suspected to have so committed, the authority appointed from the government officials not lower than level 4 of position classification shall have the power to arrest such person in order to hand over to an inquiry official for further legal action.
Section 37 In case where the authority finds out that any person engaging in a factory business violates or fails to comply with this Act or engages in a factory business in such a manner as to cause harms, injuries or troubles to the persons or property in the factory or its vicinity, the authority shall have the power to order such person to stop such violating act or to correct or improve or conform correctly or properly within the specified period.
If the authority deems it appropriate, upon approval of the Permanent Secretary or a person assigned by the Permanent Secretary, the authority shall have the power to bind and stamp on the machines to prevent them from operating during the compliance with the order of the authority under paragraph one.
Section 38 For the service of an order under this Act, the authority shall serve at the domicile or factory of the person specified in the order during the period from sunrise to sunset or during the working hours of such person(s) or may send by a registered reply mail.

In case where the order has been served by the authority but the person specified in the order refuses to receive such order, the authority shall ask an administrative official or police to accompany as a witness for the leaving of the order at such a place. If, however, the person specified in the order is not found at the domicile or a place of business of such person, a service may be made to any person of sui juris who is or works in such a place and if no person is found or if found but refuses to accept on behalf of the specified person, the order shall be posted at a noticeable place at such domicile or factory in the presence of an administrative official or police accompanying as a witness.

Upon execution by the authority under paragraph one or paragraph two, the person specified in the order shall be deemed to have received such order. If, however, the order is sent by a registered reply mail or posted, such order shall be deemed to have been received upon the expiration of fifteen working days as from the date of sending by a postman or of posting such order as the case may be.

Section 39 In case where a person engaging in a factory business intentionally fails to comply with the order of the authority under Section 37 without reasonable ground or in case where it appears that the engagement in a business of any factory may cause serious harms, injuries or troubles to the persons or property in the factory or its vicinity, the Permanent Secretary or a person assigned by the Permanent Secretary shall have the power to order such person to stop temporarily engaging in all or part of the factory business and to modify such factory or to conform within the specified period.

If the person engaging in the factory business has modified the factory or conformed within the specified period, the Permanent Secretary or a person assigned by the Permanent Secretary shall order a continuation of the factory business.

If the person engaging in the factory business fails to modify the factory or to conform within the specified period, the Permanent Secretary or a person assigned by the Permanent Secretary shall have the power to order a closure of the factory and in case of group 3 factory, the order closing the factory shall also have the effect of revoking the permit.

Section 40 The order to stop engaging in the business or to close the factory shall be posted by the authority at three noticeable places at least at such factory provided that statements prohibiting the persons performing their duties in the factory, workers or every person involved to work in the factory for the continuation of the business after the order stopping the engagement in the business or closing the factory has been given shall be provided.

Section 41 The order of the authority under Section 37 or the order of the Permanent Secretary or a person assigned by the Permanent Secretary to stop the engagement in the factory business under Section 39 paragraph one or the order to close the factory under Section 39 paragraph three shall be appealed to the Minister within thirty days as from the date of receipt of the order. The decision of the Minister shall be final.

The appeal under paragraph one shall not ease the compliance with the order of the authority or the order to stop engaging in the factory business or the order to close the factory unless otherwise ordered by the Minister.

Section 42 In case where the person engaging in the factory business fails to comply with the order of the authority under Section 37, if there is a ground for the Government to take over the operations, the Permanent Secretary or a person assigned by the Permanent Secretary shall have the power to order the authority or to assign any person to rectify for the implementation of such order. In this respect, the person engaging in the factory business must bear the expenses for such takeover for the amount actually paid together with the penalty at the rate of thirty percent per annum of the said amount.

If the Government has undertaken to solve the pollution problem or the impact on the environment caused by the factory, it shall request a subsidy from the Environment Fund under the law on the Enhancement and Conservation of National Environmental Quality Act to pay for its operations and upon receipt of the money under paragraph one from the person engaging in the factory business, the government shall reimburse for the subsidy obtained to the Environment Fund accordingly.

Section 43 The persons engaging in a business of group 2 factory and group 3 factory must pay the annual fees in accordance with the criteria, procedures, and rates as provided for in the ministerial rules throughout the period of engagement in the business. Failure to pay the fees within the specified period shall result in the payment of additional money at five percent per month and if they still refuses to pay the fees without reasonable ground, the authority shall have the power to order such person to stop the engagement in the business until the fees and additional money have been paid in full and Section 39, Section 40 and Section 41 shall apply mutatis mutandis.

Section 44 In performing the duties, the authority must present the identity card upon request of the persons involved.

The identity card of the authority shall be in accordance with the form specified by the Minister upon publication in the Government Gazette.

Chapter 3
Penalties

Section 45 Any person violating or failing to comply with the ministerial rules prescribed pursuant to Section 8 (1) (2) (3) (4) (5) or (8) or announcements of the Minister prescribed pursuant to the said ministerial rules shall be subject to a fine not exceeding two hundred thousand Baht.

Section 46 Any person violating or failing to comply with the ministerial rules prescribed pursuant to Section 8 (6) or (7) or announcements of the Minister prescribed pursuant to the said ministerial rules shall be subject to a fine not exceeding twenty thousand Baht.

Section 47 Any person producing a false result of the inspection under Section 9 shall be subject to an imprisonment not exceeding two years or a fine not exceeding two hundred thousand Baht or both.

Section 48 Any person engaging in a business of group 2 factory without notifying the authority under Section II paragraph one shall be subject to an imprisonment not exceeding six months or a fine not exceeding fifty thousand Baht or both.

Section 49 Any person engaging in a business of group 2 factory notifying of the engagement in the business incorrectly or incompletely as provided for in the ministerial rules under Section 11 paragraph two or failing to comply with Section 11 paragraph five or Section 33 shall be Subject to a fine not exceeding twenty thousand bath.

Section 50 Any person engaging in a business of group 3 factory without a permit under Section 12 paragraph one or establishing a factory without a permit under Section 12 paragraph two shall be subject to an imprisonment not exceeding two years or a fine not exceeding two hundred thousand Baht or both.

In case where the factory under paragraph one is that of the type or kind of which a number or sizes are specified in order to grant or deny an establishment in any area in accordance with the announcements prescribed pursuant to Section 32 (1), such offender

shall be subject to an imprisonment not exceeding four years or a fine not exceeding four hundred thousand Baht or both.

Section 51 Any recipient of a permit failing to comply with Section 13 paragraph one or paragraph two, Section 19, Section 28 or Section 33 shall be subject to a fine not exceeding twenty thousand Baht.

Section 52 Any recipient of a permit expanding the factory without a permit for factory expansion under Section 18 shall be subject to an imprisonment not exceeding two years or a fine not exceeding two hundred thousand Baht or both.

In case where the factory under paragraph one is that of the type or kind of which a number or sizes are specified in order to grant or deny an expansion in any area in accordance with the announcements prescribed pursuant to Section 32(1), such offender shall be subject to an imprisonment not exceeding four years or a fine not exceeding four hundred thousand Baht or both.

Section 53 Any recipient of a permit failing to comply with Section 23, Section 24 or Section 25 shall be subject to a fine not exceeding five thousand Baht.

Section 54 Any person engaging in a factory business failing to comply with Section 34 paragraph one shall be subject to a fine not exceeding twenty thousand Baht.

Section 55 Any person engaging in a factory business during the order to stop engaging in a factory business or after the order to close the factory shall be subject to an imprisonment not exceeding two years or a fine not exceeding two hundred thousand Baht or both and an additional fine of five thousand Baht daily until the cessation of the engagement in the business.

Any architect or engineer still working in the factory only in the part against which the order to stop engaging in the business has been given or still working in the factory against which the order to close has been given in order to continue the engagement in the business of the factory shall be subject to the same penalties as those for the person engaging in a factory business under paragraph one.

Any person working in a factory or any worker still working in the factory only in the part against which to order to stop engaging in the business has been given or still working in the factory against which the order to close has been given shall be presumed to be the accomplice or supporter of the offence under paragraph one as the case may be but the court may inflict the penalty to the least extent possible by taking into account the status, responsibility for the family, intention to violate the law and the substantial participation in the act.

Section 56 Any person obstructing or failing to facilitate the authority who performs the duties under Section 35 shall be subject to an imprisonment not exceeding one month or a fine not exceeding twenty thousand Baht or both.

Section 57 Any person failing to comply with the order of the authority given under Section 37 paragraph one shall be subject to an imprisonment not exceeding one year or a fine not exceeding one hundred thousand Baht or both and an additional fine not exceeding five thousand Baht throughout the period of violation or noncompliance.

Section 58 Any person doing any act to reactivate the machine(s) bound and stamped by the authority under Section 37 paragraph two shall be subject to an imprisonment not exceeding one year or a fine not exceeding one hundred thousand Baht or both.

Section 59 Any person obstructing or failing to facilitate a person assigned by the Permanent Secretary or by a person assigned by the Permanent Secretary undertaking the execution of the order under Section 42 shall be subject to an imprisonment not exceeding one year or a fine not exceeding one hundred thousand Baht or both.

Section 60 Any person doing any act causing defect or damage to the order to stop engagement in the factory business or to close the factory shall be subject to an

imprisonment not exceeding six months or a fine not exceeding fifty thousand Baht or both.

Section 61 In case where a person engaging in a factory business committing an offence under this Act, the architect or engineer working in the factory and responsible for the part of work in which such offence has been committed shall be deemed to take part in or know of the commission with the person engaging in the factory business and shall be subject to the same penalties as those for the person engaging in the factory business unless it is proved that such person does not know of or consent to the commission of such offence.

Apart from the penalties under paragraph one, the Permanent Secretary shall notify the Board on the Control of Architectural Profession or the Board on the Control of Engineering Profession of the name and commission of such person in order to proceed under the laws on architectural profession or on engineering profession accordingly.

Section 62 Any person once punished for the commission of the offence under this Act, if again committed the same offence for which he/she has been punished, the court shall consider increasing the punishment for such persons at least one-third of the imprisonment penalty or increasing the punishment for another one-half of the fine penalty for such offence.

Section 63 In case where a partnership, company or other juristic persons commit an offence under this Act, the directors, managers or any person responsible for such commission shall also be subject to the penalties provided for such offence unless it is proved that such offence has been committed without their knowledge or consent.

Section 64 In case where an offence is committed under this Act, a person residing near or adjacent to the factory in which the offence is committed or a person whose living is affected as a result of commission of the offence shall be deemed to be the injured person under the Criminal Procedure Code.

Section 65 There shall be the committees for affecting the cases in Bangkok and provincial areas as is appropriate.

Each committee for effecting the cases shall be appointed by the Minister from three legal scholars whose term of office shall be two years but upon retiring from office may be reappointed.

The vacancy from office before the term, meetings and procedures of the committees for effecting the cases shall be in accordance with the regulations prescribed by the Minister upon publication in the Government Gazette.

All offences under this Act except those under Section 50 paragraph two or Section 52 paragraph two may be effected by a fine by the committees for effecting the cases if it is regarded that the accused should not be prosecuted or inflicted with an imprisonment penalty and upon paying a fine by the accused as effected within thirty days as from the date of such effect, the case shall be deemed to be settled under the Criminal Procedure Code.

In case where the inquiry official finds out that any person committing the offence under paragraph four and such person agrees to be effected by a fine, the inquiry official shall submit the file to the committee for effecting the cases within seven days as from the date of consent of such person to be effected by a fine.

Provisional Chapter

Section 66 Any application filed and any permission granted and pending the consideration of the Grantor or performance of the applicant as granted as the case may be shall be deemed as the application or permission under this Act mutatis mutandis. In case where such application or permission is different from the application or permission

under this Act, the Grantor shall have the power to order an amendment as is necessary for the implementation of this Act.

Section 67 A permit for engineering in a factory business issued to any person pursuant to the law on factory prior to the coming into force of this Act shall remain valid until expiration of its specified period.

A permit for establishing a factory under the law on factory prior to the coming into force of this Act shall be deemed as the permit for engaging in a factory business under this Act and the recipient of such permit shall have the duty to proceed under this Act.

Section 68 All ministerial rules and announcements prescribed pursuant to the law on factory shall remain in force insofar as they do not conflict or contradict with the provisions of this Act.

Countersigned by

Anand Panyarachun

Prime Minister

(Published in the Government Gazette, Volume 109, Part 44, dated 9th April, B.E. 2535)

Rates of Fees

(1) Application	100 Baht each
(2) Permit or permit for expanding a factory	100,000 Baht each
(3) Substitute for a permit	1,000 Baht each
(4) Renewal of a permit shall be in accordance with the rate in (2)	
(5) Fee for engaging in a factory business	30,000 Baht annually

In prescribing a ministerial rule fixing the fees, different rates of the fees may be adopted by taking into account the size and business the factory involved.

ANNEX VII. THAILAND NOTIFICATION

Thailand. The Notification of the Ministry of Industry No. 1 B.E. 2541 (1998)

ISSUED PERSUANT TO THE FACTORY ACT B.E. 2535(1992)

SUBJECT : DISPOSAL OF WASTES OR UNUSABLE MATERIALS

(GARUDA EMBLEM)

THE NOTIFICATION OF THE MINISTRY OF INDUSTRY NO. 1 B.E. 2541 (1998) ISSUED PERSUANT TO THE FACTORY ACT B.E. 2535(1992) SUBJECT : DISPOSAL OF WASTES OR UNUSABLE MATERIALS (Unofficial Translation)

By the virtue of article 13(3) and Article 13(3)(a) of the Ministerial Regulation, no 2. B.E. 2535 (1992), issued pursuant to the Factory Act B.E. 2535(1992), the Minister of Industry issues a notification as follows :-

Article 1. Factory operators located in the Provinces of Bangkok Metropolis, Samut Prakarn, Nonthaburi, Pathum Thani, Samut Sakhon, Nakhon Pathom, Chon Buri, Chasoengsao, Rayong, Prachin Buri, Nakhon Ratchasima, Lamphun, Sara Buri and Phra Nakhon Si Ayutthaya which have wastes or unusable materials having characteristic and properties as defined in the Annex 1 attached to this notification, must proceed with the disposal of such waste or unusable used materials as defined in Article 2.

Article 2. It is prohibited to take the wastes or unusable materials in article 1 out of the factory except with prior approval from the Director General of the Department of Industrial Works or the person whom the Director General of the Department of Industrial Works has delegated to take them out for detoxification, disposal, discarding or landfilling with the method and at the place according to the criterion and methods as defined in the Annex 2 of this notification.

This shall, thus, come into force after the lapse of a period of 60 days from the publication in the Royal Government Gazette onwards.

Announced on the 26th May 1998.

(Signed): Somsak Thepsuthin
(Mr. Somsak Thepsuthin)
Minister of Industry.

Published in the Royal Government Gazette Volume 115, Special Part 44 Ngor. dated 5th June 1998. (B.E. 2541)

Annex 1

WASTES AND UNUSABLE MATERIALS INVENTORY
ATTACHED TO
THE NOTIFICATION OF THE MINISTRY OF INDUSTRY, NO 1,
B.E. 2541(1998)

Section 1
Industrial Non-Hazardous Wastes

Article 1. Wastes and unusable materials from production process or operation of factories with characteristics and properties as follows :-

1.1 Parts of plants e.g. roots, barks, leaves or body parts of animals e.g. bones, skins, hair and droppings.

1.2 Parts of wood.

1.3 Paper wastes.

1.4 Polymers and resins of plastic or Synthetic rubber.

1.5 Cloth, thread and fabric.

1.6 Animal's fat and oil and vegetable oil.

1.7 Natural rubbers.

1.8 Metals and metal alloys (not in salt form) e.g. , steel, aluminium, copper and brass.

1.9 Glass, mirror, tiles or ceramic tiles.

1.10 Stone, cement, sand or materials consisting of clay, sand or stone e.g. tile, brick, gypsum and concrete.

Article 2. If the wastes or unusable materials in Article 1 are contaminated or mixed with those wastes, as in the Notification of Ministry of Industry No. 6. B.E. 2540 (1997) Subject : Disposal of the Wastes and Unusable Materials dated 29th October 1997, until their original characteristic and properties are changed and turned to those as defined in Section 1 of Annex 1 of such notification, such wastes are not considered as wastes or unusable materials under this notification.

Section 2
Wastes and Unusable Materials from Specific Industrial Processes

Article 3. The wastes or unusable materials from production process or from operation of factory with type or composition as follows.

3.1 Ash from the burning of fossil fuels, biomass and combustible materials.

3.2 Scraps or waste from chopping and cutting of the parts of auto shredders, trailers, tricycles, bicycles or parts of such auto shredder wastes.

3.3 Dust from air pollution control system such as bag house, electrostatic precipitator, cyclone and scrubber wastes.

3.4 Spent catalyst from petrochemical industry, Chemical industry and Petroleum industry.

3.5 Dust from Cement kilns.

3.6 Dewatered sludges from wastewater treatment process or used water treatment process in the industrial processes.

3.7 Dewatered sludges from wastewater treatment system of tanneries.

3.8 Drilling mud from exploration and drilling of natural gas or oil.
3.9 Used refractory materials from industrial furnaces, kilns and ovens.
3.10 Used sand from sand blasting.
3.11 Used sand from foundry casting.
3.12 Slag from coal gasification.
3.13 Sulfur dioxide scrubber wastes from fossil fuel combustion process.
3.14 Scraps or dusts from cutting of leather tanned by chrom.
3.15 Wastes or tailings from extraction, beneficiation and processing of ores and minerals.

These wastes or unusable materials not having pass any treatment process, when being test for leachate extraction procedures prescribed in the Notification of the Ministry of Industry No. 6, B.E. 2540 (1997) Subject : Disposal of Wastes or Unusable Materials dated 29th October 1997 must not have characteristics and properties as wastes or unusable materials under such notification.

Annex 2

CRITERIA AND METHODS OF DETOXIFICATION, DISPOSAL, DISCARDING OR LANDFILLING ATTACHED TO THE NOTIFICATION OF THE MINISTRY OF INDUSTRY NO. 1 [B.E. 2541(1998)]

Article 1. The factory operator who wishes to detoxify, dispose, discard or landfill the wastes or unusable materials according to this notification must proceed with the following methods :-

1.1 Land filling, in order to landfill the wastes or unusable materials without having any affect to the environment, the liner system, leak detection system, gas emission and wastewater treatment system must be provided depending on type or category of wastes or unusable materials, . In addition, there must be an approval from the Industrial Works Department.

1.2 Incineration, the waste must be incinerated by controlling air emission not exceeding emission standards, according to the Notification of the Ministry of Science, Technology and Environment regarding emission standard of solid waste incinerator dated 17th June 1997.

1.3 Disposal by other methods, requiring approval form the Industrial Works Department.

1.3.1 Composting and land reclamation.

1.3.2 Recycle/reuse/recovery for only the wastes and unusable materials in article 3, Section 2 of Annex 1 in this notification.

Article 2. The factory operator who wishes to used others person's service for disposal of the wastes or unusable materials according to this notification must obtain an approval from the Industrial Works Department.

Unofficial Translation by GENCO

ANNEX VIII. THAILAND ENVIRONMENT ACT

Thailand Enhancement and Conservation of the National Environment Quality Act, 1992

ENHANCEMENT AND CONSERVATION OF NATIONAL ENVIRONMENTAL QUALITY ACT, B.E. 2535

BHUMIBOL ADULYADEJ, REX.

Given on the 29th Day of March B.E. 2535,
Being the 47th Year of the Present Reign

His Majesty King Bhumibol Adulyadej is graciously pleased to proclaim that

Whereas it is deem expedient to reform and improve the law on enhancement and conservation of national environmental quality.

Be it, therefore, enacted by the King, by and with the advice and consent of the National Legislative Assembly, acting as the National Assembly, as follows

Section 1 This Act shall be called "The Enhancement and Conservation of National Environmental Quality Act, B.E. 2535"

Section 2 This Act shall come into effect after the elapse of a period of sixty days from the date following its publication in the Government Gazette.

Section 3 The following Acts shall be repealed

1. The Enhancement and Conservation of National Environmental Quality Act, B.E. 2518.
2. The Enhancement and Conservation of National Environmental Quality Act (No. 2), B.E.2521.
3. The Enhancement and Conservation of National Environmental Quality Act (No. 3), B.E. 2522

Section 4 In this Act,

"Environment" means natural things which form the physical and biological conditions surrounding man and man-made things.

"Environmental Quality" means the balance of nature, being composed of animals, plants, natural resources and man-made objects which is for the benefit of subsistence of mankind and the sustenance of human-being and nature.

"Environmental Quality Standards" means the parameters of quality standards for water, air, noise and other conditions of the environment which are determined as the general criteria for enhancement and conservation of environmental quality.

"Fund" means the Environmental Fund.

"Pollutant" means wastes, hazardous substances and other polluting substances as well as residues, sediments or remainders of such matters, which are discharged from point sources of pollution or naturally occur in the environment, that have or are likely to have impacts on environmental quality or to cause conditions poisonous or harmful to the health and hygiene of the public, and shall mean to include radiation, heat, light, noise, odor, vibration or other nuisances emanated or discharged from point sources of pollution.

"Pollution" means the state or environment that has been affected, changed or contaminated by pollutants, resulting in deterioration of environmental quality, such as water pollution, air pollution, soil pollution.

"Point Source of Pollution" means any community, factory, building, structure, vehicle, place of business or activity or any other thing from which pollution is generated.

"Waste" means refuse, garbage, filth, dirt, wastewater, polluted air, polluting substances or any other hazardous substances which are discharged or originated from point sources of pollution, including residues, sediments or remainders of such matters, either in the state of solid, liquid or gas.

"Wastewater" means waste in liquid state including polluting or contaminating substances contained in such liquid.

"Polluted Air" means waste in gaseous state in the form of vapor, steam, exhaust, fume, odor, smoke, gas, dust, soot, ash or other polluting substances in the form of particulate matters that can be suspended in the atmospheric air.

"Hazardous Substance" means explosive substances, inflammable substances, oxidizing and peroxiding substances, toxic substances, pathogenic substances, radioactive substances, genetic transforming substances, corrosive substances, irritating substances, or other substances whether chemical or not, which may cause danger to human-being, animal, plant, property or the environment.

"Nuisance" means nuisance according to the law on public health.

"Factory" means factories according to the law on industrial plants.

"Building" means buildings according to the law on building control.

"Vehicle" means automobiles or motorcycles according to the law on automobiles, vessels according to the law on Thai vessels and aircraft according to the law on aviation.

"Monitoring Control Operator" means the person licensed to monitor, control, assess, operate and maintain wastewater treatment or waste disposal facility, or equipment, instrument, tools, appliances for control, treatment or disposal of any other pollution, which the owner or possessor of point source of pollution manages to construct and bring into operation by his own investment and expenses for the treatment of wastewaters or disposal of wastes or any other pollutants.

"Service Contractor" means the person licensed to render for hire the services of wastewater treatment or waste disposal or monitoring of environmental quality.

"Conservation Area" means the areas designated as national parks, wildlife reserves, tourism preserve and other protected areas pursuant to the governing laws related thereto.

"Local Official" means

1. President of the Municipal Council within a municipality.
2. President of the Sanitary District Board within a sanitary district.
3. Changwat Governor within a local administration organization.
4. Governor of the Bangkok Metropolitan Administration within Bangkok Metropolis.
5. Permanent Secretary of Pattaya City Administration within the City of Pattaya.
6. Head of local administrator in the administration of the local administration organization other than (1) to (5) above, established by specific law governing thereof, within such local administration organization.

"Pollution Control Official" means the person appointed by the Minister to perform the functions concerning pollution control under this Act.

"Competent Official" means the person appointed by the Minister to have power and duty to take action under this Act.

"Minister" means the Minister of Science, Technology and Environment.

Section 5 In case any provision under this Act refers to Changwat or mandates the power and duty of the Changwat Governor, such reference or mandate shall denote the inclusion of Bangkok Metropolitan Administration or the power and duty of the Governor of Bangkok Metropolitan Administration, as may be the case.

Section 6 For the purpose of public participation in the enhancement and conservation of national environmental quality, the following rights and duties may be accorded to individual person as provided by this Act or governing law related thereto:

(1) To be informed and obtain information and data from the government service in matters concerning the enhancement and conservation of environmental quality, except the information or data that are officially classified as secret intelligence pertaining to national security, or secrets pertaining to the right to privacy, property rights, or the rights in trade or business of any person which are duly protected by law.

(2) To be remedied or compensated by the State in case damage or injury is sustained as a consequence of dangers arisen from contamination by pollutants or spread of pollution, and such incident is caused by any activity or project initiated, supported or undertaken by government agency or state enterprise.

(3) To petition or lodge complaint against the offender in case of being a witness to any act committed in violation or infringement of the laws relating to pollution control or conservation of natural resources.

(4) To co-operate and assist government officials in the performance of duty relating to the enhancement and conservation of environmental quality.

(5) To strictly observe the provisions of this Act or other laws concerning the enhancement and conservation of environmental quality.

Section 7 In order to encourage public participation in the promotion and conservation of environmental quality, non-governmental organizations (NG0s) having the status of a juristic person under Thai law or foreign law which are directly engaged in activities concerning environmental protection or conservation of natural resources without any objective to be involved in politics or to make profits from the engagement in such activities, shall be entitled to register with the Ministry of Science, Technology and Environment as the NG0s for environmental protection and conservation of natural resources in accordance with the rules, procedures and conditions prescribed by ministerial regulation.

Section 8 The NG0s that have been registered pursuant to section 7 may request for government assistance or support in the following matters:

(1) The organization of volunteers to assist in the performance of duty of government officials under this Act or other laws concerning the enhancement and conservation of environmental quality.

(2) Public relations campaign and dissemination of information or data to promote public awareness and proper understanding and knowledge about environmental protection and conservation of nature and natural resources.

(3) Providing assistance to people in certain areas of the country to initiate projects or activities for environmental protection and conservation of natural resources in such areas.

(4) Conducting study and research in respect of environmental protection and conservation of natural resources and bringing to the attention of the Government or agencies concerned on what are the viewpoints and suggestions based upon the outcome of such study and research.

(5) Providing legal aid to people who are in jeopardy of or afflicted by pollution damage caused by leakage of pollutants or contamination as well as acting as representative of such pollution victims to bring lawsuit and litigate claim in court for compensation or damages to which they are entitled as legal remedies.

In case any registered NG0s, in the carrying out of activities indicated in the first paragraph, encounter problems or difficulties and request for help from the National Environment Board, the Prime Minister shall, with the recommendation of the National Environment board, have the power to direct for appropriate recourse or order the government agency or state enterprise concerned to render assistance or facilitation as seen fit under the circumstances.

The Fund Committee, with the approval of the National Environment Board, may consider to allocate grants or loans in support of any activity of the registered NG0s as deemed appropriate.

The registered NG0s may propose for nomination of candidates as representatives of the private sector to be appointed by the cabinet as qualified members of the National Environment Board.

In case any registered NGO's activities are undertaken by causing disturbances or contrary to public order or unsuitable, the Minister shall have the power to revoke the registration of the NGO involving in such activities.

Section 9 In case there is an emergency or public danger arising from natural disaster or pollution caused by contamination and spread of pollutants which will, if left without any remedial actions, seriously endanger the safety of life, body or health of the people, or aggravated cause damage to the properties of the people or the State, the Prime Minister shall have the power to order, as deemed appropriate, government agencies, state enterprises or any persons, including the persons who are or may be the victims of such danger or damage, to take prompt action, individually or jointly, in order to be able to control, extinguish or mitigate the adverse effects of such danger or damage. In case any polluters are known and can be identified, the Prime Minister shall be empowered to enjoin such persons from any acts which may aggravate the adverse effects of pollution during the occurrence of such endangering incident.

The Prime Minister may delegate the power to give orders pursuant to the first paragraph to the Changwat Governor to exercise such power and act on his behalf within the territorial jurisdiction of that Changwat. The said delegation of power shall be made by a written order and published in the Government Gazette.

When any order is given by the Prime Minister by virtue of the first paragraph, or by the Changwat Governor acting on behalf of the Prime Minister by virtue of the second paragraph, such order shall be published in the Government Gazette without delay.

Section 10 In order to prevent, remedy, extinguish or mitigate the emergency or danger of pollution envisaged by section 9, the Minister shall determine preventive measures and prepare a contingency plan to rectify the situation in advance.

Section 11 The Prime Minister and the Minister of Science, Technology and Environment shall have charge and control of the execution of this Act, insofar as it is concerned with their respective powers and duties conferred upon them under this Act.

The Minister of Science, Technology and Environment shall have the power to appoint pollution control officials and other competent officials, issue ministerial regulations prescribing fees not exceeding the rates attached hereto and prescribing other activities for the execution of this Act.

The Ministerial Regulations shall come into force upon their publication in the Government Gazette.

Chapter I
National Environment Board

Section 12 There shall be a National Environment Board consisting of the Prime Minister as the Chairman, a Deputy Prime Minister designated by the Prime Minister as the first Vice Chairman, the Minister of Science, Technology and Environment as the second Vice Chairman, the Minister of Defense, the Minister of Finance, the Minister of Agriculture and Cooperatives, the Minister of Transport and Communications, the Minister of Interior, the Minister of Education, the Minister of Public Health, the Minister of Industry, the Secretary-General of the National Economic and Social Development Board, the Secretary-General of the Board of Investment, the Director of the Bureau of the Budget as members *ex officio* and members qualified in environmental matters not more than eight persons of which no less than half shall be representatives from the private sector and the Permanent Secretary of the Ministry of Science, Technology and Environment as member and secretary.

The appointment of qualified members shall be made by drawing from persons who are knowledgeable and known for their expertise, contributions and experiences in the matters concerning the enhancement and conservation of environmental quality.

Section 13 The National Environment Board shall have the power and duty as follows

(1) To submit policy and plan for enhancement and conservation of national environmental quality to the cabinet for approval.

(2) To prescribe environmental quality standards pursuant to section 32.

(3) To consider and give approval to the Environmental Quality Management Plan proposed by the Minister according to section 35.

(4) To consider and give approval to the Changwat Action Plan for environmental quality management according to section 37.

(5) To make recommendations to the cabinet in respect of financial, fiscal, taxation and investment promotion measures for the implementation of the policy and plan for enhancement and conservation of national environmental quality.

(6) To propose for amendment or improvement of laws relating to the enhancement and conservation of environmental quality to the cabinet.

(7) To consider and give approval to the action plan for prevention and remedy of danger caused by contamination of pollutants or spread of pollution proposed by the Pollution Control Committee pursuant to section 53 (1).

(8) To consider and give approval to the setting of emission or effluent standards proposed by the Minister pursuant to section 55.

(9) To supervise, oversee and expedite the enactment of royal decrees and issuance of ministerial regulations, rules, local ordinances, notifications, bye-laws and orders which are necessary to ensure systematic operation of the laws relating to enhancement and conservation of environmental quality to the fullest extent possible.

(10) To submit opinion to the Prime Minister for his directions in case it appears that any government agency or state enterprise infringes or refrains from complying with the laws and regulations for environmental protection which may cause extensive damage to the environment.

(11) To specify measures for the strengthening and fostering of co-operation and co-ordination among government agencies, state enterprises and the private sector in matters concerning the promotion and conservation of environmental quality.

(12) To supervise the Fund management and administration.

(13) To submit reports on national environmental quality situation to the cabinet at least once year.

(14) To perform other functions as may be provided by this Act or other laws to be within the authority of the National Environment Board.

Section 14 A qualified member appointed by the cabinet shall hold office for a term of three years and may be re-appointed for a period of not more than one consecutive term.

In case an additional appointment of qualified member is made during the term of those members who have already been appointed to hold office, the term of additional membership shall be equal to the remainder of the term of those members who have already been appointed before.

Section 15 In addition to the expiration of the term of office according to section 14, a qualified member appointed by the cabinet shall vacate office upon

(1) death;

(2) resignation;

(3) being a bankrupt;

(4) being an incompetent or quasi-incompetent person;

(5) being punished by a final judgment to a term of imprisonment except for an offence committed through negligence or a petty offence.

(6) Being dismissed by the cabinet for incompetence or misconduct or having vested interests in any activity or business that may have a direct impact on or adversely affect the environmental quality.

When a qualified member vacates office before the expiration of his term of office, the cabinet may appoint another person to fill the vacancy and such person shall hold office only for the remaining term of his predecessor.

Section 16 In convening the National Environment Board meeting, if the Chairman is absent or unable to perform the function, the first Vice Chairman shall act as the Chairman. If the Chairman and the first Vice Chairman are both absent or unable to perform the function, the second Vice Chairman shall act as the Chairman. If the Chairman and both the two Vice Chairmen are all absent or unable to perform the function, the members who attend the meeting shall elect one of the attending members to act as the chairman of the meeting.

Section 17 A meeting of the National Environment Board requires the presence of not less than one-half of the total member of its members to constitute a quorum.

The decision of a meeting shall be made by a majority of votes. In casting votes, each member shall have one vote. In case of an equality of votes, the Chairman of the meeting shall have an additional vote as a casting vote.

Section 18 The National Environment Board may appoint an expert committee or subcommittee to consider or carry out any matter as may be entrusted by the National Environment Board.

Section 16 and section 17 shall apply *mutatis mutandis to* the meeting of the expert committee or subcommittee.

Section 19 The National Environment Board shall have the power to require government agencies, state enterprises and other persons to deliver documents relating to the examination of impacts on environmental quality and documents or data concerning the projects or work plans of such government agencies, state enterprises and persons for its consideration. For this purpose, the Board may, summon persons concerned to give explanation. If the Board is of the opinion that any project or work plan may seriously affect the environmental quality, it shall recommend remedial measures to the cabinet.

In case the documents or data required to be delivered to the National Environment Board pursuant to the first paragraph are relevant to trade secrets in the nature of a patent and protected by the law on. patent rights, the National Environment Board shall specify suitable measures and methods for preventing such documents or data from being disclosed to anyone to ensure that they shall only be used strictly for the purpose of this section.

Section 20 In the performance of its function, the National Environment Board, the expert committee or the sub-committee may invite any person to present facts, explanation, opinion or technical advice as it deems fit and may request co-operation from any person with a view to ascertaining any fact or surveying any activity which may have an adverse effect on environmental quality.

Section 21 In the performance of its duties under this Act, the National Environment Board may entrust the Office of Environmental Policy and Planning, the Pollution Control Department or the Environmental Quality Promotion Department under the Ministry of Science, Technology and Environment with the operation or preparation of propositions to be made to the National Environment Board for further actions.

Chapter II
Environmental Fund

Section 22 There shall be established a fund called the "Environmental Fund" in the Ministry of Finance with the following moneys and properties :

(1) Money from the Fuel Oil Fund in the amount determined by the Prime Minister.

(2) Money transferred from the Revolving Fund for Environmental Development and Quality of Life established by the Annual Budget for the Fiscal Year of B.E. 2535 **Act,** B.E. 2535.

(3) Service fees and penalties collected by virtue of this Act.

(4) Grants from the Government from time to time.

(5) Moneys or properties donated by donors in the private sector both domestic and foreign, by foreign governments or by international organizations.

(6) Interest and benefits accrued from this Fund.

(7) Other moneys received for the operation of this Fund.

The Comptroller-General's Department, Ministry of Finance, shall keep the moneys and properties of the Environmental Fund and make disbursements from the fund in accordance with this Act.

Section 23 Fund disbursements shall be made for the following activities and purposes

(1) As grants to government agency or local administration for investment in and operation of the central wastewater treatment plant or central waste disposal facility, including the acquisition and procurement of land, materials, equipment, instrument, tools and appliances necessary for the operation and maintenance of such facility.

(2) As loans to local administration or state enterprise for making available of air pollution control system, wastewater treatment or waste disposal facilities to be used specifically in the activities of such local administration or state enterprise.

(3) As loans to private person in case such person has the legal duty to make available and install an on-site facility of his own for the treatment of polluted air, wastewater or waste disposal or any other equipment for the control, treatment or eliminate pollutants that are generated by his activity or business undertaking, or such person is licensed to undertake business as a Service Contractor to render services of wastewater treatment or waste disposal under this Act.

(4) As aids or grants to support any activity concerning the promotion and conservation of environmental quality as the Fund Committee sees fit and with the approval of the National Environment Board.

(5) As expenditures for administering the Fund.

Section 24 There shall be a Fund Committee consisting of the Permanent Secretary of the Ministry of Science, Technology and Environment as the Chairman, the Permanent Secretary of the Ministry of Agriculture and Cooperatives, the Secretary-General of the National Economic and Social Development Board, the Director of the Bureau of the Budget, the Director-General of the Department of Local Administration, the Comptroller-General of the Comptroller-General's Department, the Director-General of the Department of Public Works, the Director-General of the Department of Industrial Works, the Director-General of the Department of Mineral Resources, the Director-General of the Pollution Control Department, the Director-General of the Environmental Quality Promotion Department and not more than five qualified persons appointed by the National Environment Board as members and the Secretary-General of the Office of Environmental Policy and Planning as member and secretary.

Section 14 and section 15 shall apply *mutatis mutandis* to the holding office of the qualified members of the Fund Committee.

Section 25 The Fund Committee shall have the power and duty as follows

(1) To consider on Fund allocation for use in the activities prescribed by section 23.

(2) To prescribe rules, conditions, procedures and methods concerning application for allocation or loan from the Fund.

(3) To lay down administrative rules and procedures concerning the power, duties and working methods of the Fund managers according to section 29 and section 30 as well as mechanisms for co-ordination among the Fund Committee, the Comptroller-General's Department and the Fund managers according to section 29 and section 30.

(4) To lay down rules and procedures for the receipt and disbursement of moneys from the Fund.

(5) To fix durations for repayment of loans from the Fund according to section 23 (2) or (3) as well as interest rates and securities as necessary and appropriate.

(6) To determine the ratio and criteria for deduction of service fees and penalties that are required by section 93 to be remitted to the Fund.

(7) To perform any other functions provided under this Act.

The prescription of rules according to sub-section (2), (3) or (4) and guidelines for action under sub-section (1) or (5) shall be approved by the National Environment Board.

The Fund Committee may appoint a subcommittee to consider or carry out any matter as may be entrusted by the Fund Committee.

Section 26 Section 16, section 17 and section 20 shall apply *mutatis mutandis* to the performance of functions of the Fund Committee and the subcommittee appointed by the Fund Committee.

Section 27 In consideration to allocate money from the Fund for the purpose of section 23 (1), the Fund Committee shall give first priority to the request for allocation under the Changwat Action Plan for environmental quality management according to section 39 to construct or operate the wastewater treatment plant or waste disposal facility, for which certain amount of government budget has been earmarked or revenues of the local administration have been allocated as additional contributions to the Fund allocation.

The proportion between the government budget or contributions from the local revenues and the Fund allocation to be determined by the Fund Committee according to the first paragraph shall be determined in accordance with the rules laid down by the National Environment Board.

Section 28 The Fund allocation as loans to the local administration, state enterprise or private person pursuant to section 23 (2) or (3) shall be determined by the Fund Committee in accordance with the rules and conditions stipulated by the National Environment Board.

In order to encourage compliance with this Act, the Fund Committee may, with the approval of the National Environment Board, allocate from the Fund as an exceptional long-term loan to any local administration, state enterprise, or private person and may determine to reduce the interest rates or make exemption to the payment of such interest as deemed appropriate.

Section 29 The Comptroller-General of the Comptroller-General's Department, Ministry of Finance, shall be the Fund manager in relation to such portion of the Fund to be allocated as grants to the government agency or the local administration for investment in and operation of the central facility for wastewater treatment or waste disposal according to section 23 (1) and those portions of the Fund to be allocated for the purposes other than those provided by section 23 (2) and (3).

Section 30 The Fund Committee may authorize an appropriate financial institution owned by the State or the Industrial Financing Corporation of Thailand to be the Fund manager in relation to such portion of the Fund that will be allocated as loans to the local administration, state enterprise or private person pursuant to section 23 (2) or (3).

In carrying out the management of Fund according to the First paragraph, the Fund manager has the duty to study and analyze the investment and technical feasibility of the project and shall be empowered to enter the loan agreement on behalf of the Fund Committee in the capacity as the lender, to keep and disburse moneys to the borrowers from this portion of the Fund in accordance with the terms and conditions of the loan agreement, to pursue, demand and receive repayments and interest from the borrowers in order to pay back to the Fund, and shall be empowered to lay down rules and procedures, with the approval of the Fund Committee, for such matters.

Under the loan agreement to be entered into according to the second paragraph, there must be a condition stipulated as an essential element of the agreement that the borrower shall have the duty to make use of the loan specifically for the purpose of meeting the requirements with which the borrower has the legal duty to comply under this Act or other related laws.

Section 31 The moneys received into the Fund and kept by the Comptroller-General's Department, Ministry of Finance shall be managed by deposit in saving or fixed accounts with State owned financial institutions in order to earn accrued interest.

All moneys earned by the Fund according to section 22 shall be paid into its account for the purpose of uses in the activities indicated in section 23 and shall not be remitted to the Treasury as revenues of the Government.

Chapter III
Environmental Protection

Part 1

Environmental Quality Standards

Section 32 For the purpose of environmental quality enhancement and conservation, the National Environment Board shall have the power to prescribe by notifications published in the Government Gazette the following environmental quality standards :

(1) Water quality standards for river, canal, swamp, marsh, lake, reservoir and other public inland water sources according to their use classifications in each river basin or water catchments.

(2) Water quality standards for coastal and estuarine water areas.

(3) Groundwater quality standards.

(4) Atmospheric ambient air standards.

(5) Ambient standards for noise and vibration.

(6) Environmental quality standards for other matters.

The prescription of environmental quality standards pursuant to the foregoing paragraph shall be based upon scientific knowledge, principles, criteria and evidence related thereto and shall also take into account the practicability of such standards from the viewpoint of economic, social and technological considerations.

Section 33 The National Environment Board shall, if deemed reasonable, have the power to prescribe special standards, which are higher than the environmental quality standards prescribed pursuant to section 31, for the protection of areas designated as conservation or environmentally protected area according to section 42, or areas designated according to section 44, or pollution control areas designated pursuant to section 58.

Section 34 The National Environment Board shall have the power to make appropriate modifications and improvements to the prescribed environmental quality standards in the light of scientific and technological progresses and changes in economic and social conditions of the country.

Part 2
Environmental Quality Management Planning

Section 35 The Minister shall, with the approval of the National Environment Board, formulate an action plan called "Environmental Quality Management Plan" for implementation of the national policy and plan for enhancement and conservation of environmental quality determined by virtue of section 13 (1).

The Environmental Quality Management Plan pursuant to the first paragraph shall be published in the Government Gazette.

It shall be the duty of all government agencies concerned to take actions within their powers and functions that are necessary for effective implementation of the Environmental Quality Management Plan and in order to ensure that actions are taken to achieve the objectives and goals as prescribed, it shall be the duty of the Ministry of Science, Technology and Environment to give advice to government agencies and state

enterprises which are concerned with the formulation of work plans or the taking of any actions with a view to implementing the Environmental Quality Management Plan.

Section 36 The Environmental Quality Management Plan pursuant to section 35 may be a short, intermediate or long-term plan, as appropriate, and should contain work plan and guidance for action in the following matters:

(1) Management of air, water and environmental quality in any other area of concerns.

(2) Pollution control from point sources.

(3) Conservation of natural environment, natural resources or cultural environment pertaining to aesthetic values.

(4) Estimation of financing to be appropriated from government budget and allocated from the Fund which is necessary for implementation of the Plan.

(5) Scheme for institutional arrangements and administrative orders by which co-operation and co-ordination among government agencies concerned and between the public service and private sector could be further promoted and strengthened, including the determination of a manpower allocation scheme which is required for implementation of the Plan.

(6) Enactment of laws and issuance of regulations, local ordinances, rules, orders and notifications necessary for implementation of the Plan.

(7) Scheme for inspection, monitoring and assessment of environmental quality by which the results of implementation of the Plan and enforcement of law related thereto can be evaluated objectively.

Section 37 After the Environmental Quality Management Plan has been published in the Government Gazette, it shall be the duty of the Governor of the Changwat, in which there is a locality designated as environmentally protected area according to section 43, or as pollution control area according to section 59, to formulate an action plan for environmental quality management at Changwat level and submit it to the National Environment Board for approval within one hundred and twenty days from the date on which the Governor of that Changwat is directed by the National Environment Board to prepare the Changwat action plan for environmental quality management. If, however, there is a reasonable ground, the said duration may be extended as appropriate by the National Environment Board.

In preparing a Changwat Action Plan for the pollution control area according to section 59, the Governor shall incorporate into it the action plan for mitigation and elimination of pollution prepared by the local authority pursuant to section 60 and the local action plan shall form an integral part of the Changwat Action Plan.

In case there is any Changwat, in which no locality is designated as an environmentally protected area according to section 43, or as pollution control area according to section 59, that is nevertheless desirous to enhance and conserve the environmental quality within the limits of its territorial jurisdiction, the Governor of that Changwat may prepare a Changwat Action Plan, within the framework of and in conformity with the requirements of the Environmental Quality Management Plan, and submit it to the National Environment Board for approval.

Section 38 The Changwat Action Plan to be submitted to the National Environment Board shall be an action plan which proposes a system of integrated management of environmental quality in conformity with the guidance specified in the Environmental Quality Management Plan, taking into account the severity of the problems and economic, social and environmental conditions of that Changwat, and should address and contain essential elements in the following matters

(1) Plan for control of pollution from point sources.

(2) Plan for procurement and acquisition of land, materials, equipment, tools and appliances which are essential for the construction, installation, improvement, modification, repair, maintenance and operation of central wastewater treatment plants or central waste disposal facilities belonging to government agency or local administration concerned.

(3) Plan for collection of taxes, duties and service fees for operation and maintenance of central wastewater treatment plants or central waste disposal facilities referred to in sub-section (2) above.

(4) Plan for inspection, monitoring and control of wastewaters and other waste matters which are discharged from point sources of pollution.

(5) Law enforcement plan for the prevention and suppression of violation or infringement of laws and regulations pertaining to pollution control and conservation of nature, natural resources and cultural environment pertaining to aesthetic values.

Section 39 The Changwat Action Plan for environmental quality management to be given first priority for the consideration of the National Environment Board must propose an estimate of budgetary appropriation and allocation from the Fund for the construction or procurement for the acquisition of a central wastewater treatment plant or a central waste disposal facility pursuant to section 38 (2). In case any Changwat is not ready to take steps for the procurement and acquisition of the central wastewater treatment plant or the central waste disposal facility, it may instead propose a plan to promote private investment in the construction and operation of wastewater treatment or waste disposal facilities in order to make available of such services within its jurisdiction.

The Changwat Action Plan to be prepared according to the first paragraph with a request for budgetary appropriation and allocation from the Fund shall be accompanied by drawings, plans, specifications and an estimated price of the project for construction, installation, improvement, modification, repair, maintenance as well as the process and method for operation of the proposed central wastewater treatment plant or central waste disposal facility.

For the purpose of approving the Changwat Action Plan with a request for budgetary appropriation in accordance with the first paragraph, the Office of Environmental Policy and Planning shall be responsible for the gathering and analysis of the Changwat Action Plans for environmental quality management in order to make a proposal for annual budgets of the Office to be earmarked specifically for this purpose.

Section 40 In case the management of environmental quality in any matters will have to be carried out in an area adjoining the territorial jurisdictions of two or more provinces due to the geographical conditions or the characteristics of the natural ecosystems of that area, or for the purpose of a sound, systematic and proper management in accordance with the principle of integrated management of environmental quality and natural resources, the Governors of the relevant provinces shall jointly prepare the action plan mandatory required by section 37.

Section 41 In case any Changwat, which is mandatory required to prepare the action plan according to section 37, fails or is incapable to evolve such a plan, or has prepared and submitted the plan as required but failed to get the approval of the National Environment Board for any reason, the National Environment Board shall consider the nature of the problems encountered by that Changwat and evaluate whether its environmental quality is adversely affected to such an extent that any action is warrant to rectify the situation. If action is deemed necessary, the National Environment Board shall propose to the Prime Minister to issue an order directing the Ministry of Science, Technology and Environment to prepare the Changwat Action Plan on behalf of the Changwat in question.

Part 3
Conservation and Environmentally Protected Areas

Section 42 Protection and management of areas within the limits of national parks and wildlife reserves shall be in accordance with the Environmental Quality Management Plan effective by virtue of section 35 and governed by the laws related thereto.

Section 43 In case it appears that any area is characterized as watershed area, or characterized by unique natural ecosystems which are different from other areas in general, or naturally composed of fragile ecosystems which are sensitive and vulnerable to destruction or impacts of human activities, or worthy of being conserved due to its natural or aesthetic values or amenities, and such area is yet to be designated as a conservation area, the Minister shall, with the advice of the National Environment Board, be empowered to issue ministerial regulation designating such area as an environmentally protected area.

Section 44 In issuing the ministerial regulation pursuant to section 43, any one or more of the following protective measures shall be prescribed hereunder

(1) Land use prescriptions for preserving the natural conditions of such area or for preventing its natural ecosystems or its aesthetic values or amenities from being adversely impacted.

(2) Prohibition of any acts or activities that may be harmful or adversely affect or change the pristine state of the ecosystems of such area.

(3) Specifying types and sizes of projects or activities undertaken by government agencies, state enterprises or private entities, to be constructed or operated in such area, which shall have the legal duty to submit reports of environmental impact assessment.

(4) Determination of management approach and method specific to the management of such area including the scope of functions and responsibilities of relevant government agencies for the purpose of co-operation and co-ordination that are conducive to efficient performance of work towards the preservation of natural conditions or ecosystems or aesthetic values and amenities in such area.

(5) Prescriptions of any other protective measures which are deemed proper and suitable to the conditions of such area.

Section 45 In any area, despite having been designated as a conservation area, a master town and country plan area, a specific town and country plan area, a building control area, an industrial estate area pursuant to the governing laws related thereto, or designated as a pollution control area pursuant to this Act, but which nevertheless appears to have been adversely affected by environmental problems which assume a critical proportion to such an extent that an immediate action has become imperative and yet no action is taken by government agencies concerned to rectify the situation due to a lack of clear legal authorization or otherwise failure to do so, the Minister shall, with the approval of the National Environment Board, propose for a cabinet authorization to take any one or several protective measures provided by section 44, as necessary and appropriate, in order to control and solve the problems in such area.

When cabinet authorization is obtained as provided in the first paragraph, the Minister shall, by notification published in the Government Gazette, determine the limits of such area and prescribe in detail the protective measures and the duration for which such measures shall be effectively taken therein.

With the approval of the National Environment Board and the cabinet, the duration of effectiveness specified according to the second paragraph may be extended by notification published in the Government Gazette.

Part 4
Environmental Impact Assessment

Section 46 For the purpose of environmental quality promotion and conservation, the Minister shall, with the approval of the National Environment Board, have the power to specify, by notification published in the Government Gazette types and sizes of projects or activities, likely to have environmental impact, of any government agency, state enterprise or private person, which are required to prepare reports on environmental assessment for submission to seek approval in accordance with section 47, section 48 and section 49.

In the notification issued according to the first paragraph, procedures, rules, methods and guidelines shall be laid down for the preparation of environmental impact assessment report for each type and size of project or activity, including related documents that are required to be filed together with the report.

In case there has been an environmental impact assessment concerning project or activity of any particular type or size, or site selection for such project or activity in any particular area and such assessment can be used as a standard assessment applicable to the project or activity of the same type or size or to the site selection of such project or activity in the area of similar nature, the Minister may, with the approval of the National Environment Board, issue a notification in the Government Gazette exempting such project or activity of the same or similar nature from the requirement of environmental impact assessment, provided that the proponent of such project or activity shall express its consent to comply with various measures prescribed in the environmental impact assessment report which is applicable as the standard for assessment of such project or activity in accordance with the rules and methods specified by the Minister.

Section 47 In case the project or activity which is required to prepare the environmental impact assessment according to section 46 is the project or activity of a government agency or of a state enterprise or to be jointly undertaken with private enterprise which is required the approval of the cabinet in accordance with official rules and regulations, the government agency or state enterprise responsible for such project or activity shall have the duty to prepare the environmental impact assessment report at the stage of conducting a feasibility study for such project, such report shall be filed with the National Environment Board for its review and comments and then submitted to the cabinet for consideration.

In considering to give approval to the environmental impact assessment report filed according to the first paragraph, the cabinet may as well request any person or institution, being an expert or specialized in environmental impact assessment, to study and submit report or opinion for its consideration thereof.

For project or activity of government agency or state enterprise which is not required to be approved by the cabinet according to the first paragraph, the government agency or state enterprise responsible for such project or activity shall prepare and file the environmental impact assessment report in order to obtain approval prior to the initiation of such project or activity in accordance with the rules and procedures as provided by section 48 and 49.

Section 48 in case the project or activity which is required by section 46 to prepare the environmental impact assessment report is the project or activity which is required by law to obtain permission prior to construction or operation, the person applying for the permission shall have the duty to file the environmental impact assessment report with the permitting authority under such law and with the Office of Environmental Policy and Planning simultaneously. The report to be filed as aforesaid may be made in the form of an initial environmental examination (I.E.E.) in accordance with the rules and procedures determined by the Minister pursuant to section 46, second paragraph.

The official who is legally authorized to grant permission shall withhold the granting of permission for the project or activity referred to in the first paragraph until having been notified by the Office of Environmental Policy and Planning of the result of consideration pertaining to the review of the environmental impact assessment report in accordance with section 49.

The Office of Environmental Policy and Planning shall examine the environmental impact assessment report and related documents filed therewith. If it is found that the report as filed is not correctly made in accordance with the rules and procedures specified by virtue of section 46, second paragraph, or the accompanied documents and data are incomplete, the Office of Environmental Policy and Planning shall notify the person applying for permission who files the report within fifteen days from the date of receiving such report.

In case the Office of Environmental Policy and Planning finds that the environmental impact assessment report together with related documents as filed is duly made and completed with the data as required, or has been duly amended or modified in accordance with the foregoing third paragraph, it shall review and make preliminary comments on the report within thirty days from the date of receiving such report in order that the report together with the preliminary comments shall be referred to the committee of experts for further consideration.

The appointment of the committee of experts according to the foregoing fourth paragraph shall be in accordance with the rules and procedures determined by the National Environment Board. The committee shall be composed of expert members who are qualified or specialized in various fields of related disciplines and the authority legally competent to grant permission for the given project or activity under review, or its representative, shall be included in its membership.

Section 49 The review and consideration by the committee of experts according to section 48 shall be carried out within forty-five days from the date of receiving the environmental impact assessment report from the Office of Environmental Policy and Planning. If the committee of experts fails to conclude its review and consideration within the said period, the report shall be deemed to have been approved by it.

In case the committee of experts approves or is deemed to have given approval to the report, the official legally empowered to grant permission shall accordingly order that the permission be granted to the person who applies for it.

In case approval of the report is denied by the committee of experts, the permitting authority shall withhold the granting of permission to the person applying for it until such person will resubmit the

environmental impact assessment report that has been amended or entirely redone in conformity with the guidelines and detailed requirements determined by the order of the committee of experts.

When such person has resubmitted the environmental impact assessment report that has been amended or entirely redone, the committee of experts shall review and conclude its consideration within thirty days from the date of receiving the resubmitted report, If the committee of experts fails to conclude its review and consideration within the said period, it shall be deemed that the committee has approved the report and the permitting authority shall accordingly grant permission to the person who applies for it.

In case it is deemed reasonable the Minister may issue notification in the Government Gazette requiring that the project or activity of the type and size specified by the notification issued by virtue of section 46 also file the environmental impact assessment report when the application is made for renewal of permission for such project or activity in accordance with the same procedures as applicable to the application for the permission.

Section 50 For the purpose of review and consideration of the environmental impact assessment report pursuant to section 48 and section 49 and site inspection is deemed appropriate, the committee of experts or the competent official assigned by the committee shall be authorized to inspect the site of the project or activity identified in the report for which approval thereof is sought.

When the committee of experts has approved the environmental impact assessment report pursuant to section 49, the official who is legally competent to grant permission or the renewal of permission shall stipulate as the conditions of permission or renewal thereof all the mitigation measures proposed in the environment impact assessment report and all such conditions shall be deemed the conditions prescribed by virtue of the governing laws on the subject matter.

Section 51 For the purpose of compliance with section 47 and section 48, the Minister may, with the approval of the National Environment Board, require that the environmental impact assessment report as required by section 46 be prepared or certified by the person who is licensed to be a specialist in environmental impact assessment.

Application and issuance of license, qualifications of specialists who will be eligible to prepare environmental impact assessment reports, control of the licensee's performance, renewal of license, issuance of certificate in lieu of the license, suspension or revocation of the license and fee payments for the application and issuance of license shall be in accordance with the rules, procedures and conditions stipulated by ministerial regulation.

Chapter IV

Pollution Control

Part 1

Pollution Control Committee

Section 52 For the purpose of pollution control under this Act, there shall be a committee called the "Pollution Control Committee" (PCC) which consists of the Permanent Secretary of the Ministry of Science, Technology and Environment as the Chairman, the Director-General of the Department of Local Administration, the Director-General of the Police Department, the Director-General of the Department of Land Transport, the Director-General of the Harbor Department, the Director-General of the Department of Public Works, the Director-General of the Department of Mineral Resources, the Director-General of the Department of Industrial Works ' the Director-General of the Health Department, the Director-General of the Department of Agriculture, the Director-General of the Department of Environmental Quality Promotion, the Secretary-General of the Office of Environmental Policy and Planning, the Permanent Secretary for the Bangkok Metropolitan Administration and not more than five qualified persons appointed by the National Environmental Board as members and the Director-General of the Department of Pollution Control as member and secretary.

Section 14 and section 15 shall apply *mutatis mutandis* to the holding office of the qualified members in the Pollution Control Committee.

Section 53 The Pollution Control Committee shall have the power and duty as follows

1. To submit an action plan for prevention or remedy of pollution hazards or contamination to the National Environment Board.

2. To give opinion and recommend the National Environment Board on proposed amendments to or improvement of any laws concerning the control, prevention, reduction or eradication of pollution.

3. To propose incentive measures regarding taxation and private, investment promotion in relation to pollution control and promotion and conservation of environmental quality to the National Environment Board.

4. To recommend the National Environment Board on the determination of service fee rates for the central waste water treatment or central waste disposal services of the government.

5. To give advice to the Minister on the setting of emission or effluent standards under section 55.

6. To give advice to the Minister concerning the types of point sources of pollution that will be required to comply with section 68 and section 69.

7. To make recommendation on the issuing of ministerial regulations specifying the types and categories of hazardous wastes under section 79.

8. To coordinate government agencies, state enterprises and the private sector in their actions to control, prevent, mitigate or eradicate pollution.

9. To prepare and submit the report on pollution situation to the National Environment Board once a year.

10. To consider and resolve on the challenge to the order of the pollution control official under this Act.

11. To perform other functions designated by this Act or other law to be the power and duty of the Pollution Control Committee.

12. To carry out other matters assigned by the National Environment Board.

The Pollution Control Committee may appoint a subcommittee to consider or carry out any matter as may be assigned by the Pollution Control Committee.

Section 54 Section 16, section 17 and section 20 shall apply *mutatis mutandis* to the performance of functions of the Pollution Control Committee and subcommittee.

Part 2
Emission or Effluent Standards

Section 55 The Minister shall, with the advice of the Pollution Control Committee and the approval of the National Environment Board, have the power to publish notification in the Government Gazette prescribing emission or effluent standards for the control of wastewater discharge, polluted air emissions, or discharge of other wastes or pollutants from point sources into the environment, in order to meet the environmental quality standards set by virtue of this Act for the conservation of national environmental quality.

Section 56 In case there have been standards prescribed by virtue of the other laws concerning wastewater discharges, polluted air emissions, or discharge of other wastes or pollutants from point sources of pollution into the environment and such standards are no less stringent than the emission or effluent standards set by the Minister by virtue of section 55, such standards shall continue to be effective by virtue of the laws related thereto. If however, such standards are less stringent than the emission or effluent standards set by the Minister pursuant to section 55, the government agencies empowered by such laws shall amend such standards in conformity with the emission or effluent standards under this Act. If there is any obstacle preventing from doing so, the National Environment Board shall resolve on such matter and the government agencies concerned shall act in accordance with such resolution.

Section 57 In case any government agency is empowered by the other law to prescribe emission or effluent standards in any matter, but that government agency fails to exercise its power, the Minister shall, with the recommendation of the Pollution Control Committee and with the approval of the National Environment Board, publish notification in the Government Gazette prescribing the emission or effluent

standards in question and such standards shall be deemed to have been set by the governing law on such matter.

Section 58 If it is deemed reasonable, the Changwat Governor shall have the power to publish notification in the Government Gazette prescribing a special set of emission or effluent standards applicable to the pollution control area designated by section 59, higher than the standards set pursuant to section 55 or the standards set by virtue of other law which remain in force according to section 56.

Part 3
Pollution Control Area

Section 59 In case it appears that any locality is affected by pollution problems and there is a tendency that such problems may be aggravated to cause health hazards to the public or adverse impact on the environmental quality, the National Environment Board shall have power to publish notification in the Government Gazette designating such locality as a pollution control area in order to control, reduce and eliminate pollution.

Section 60 For the purpose of the Changwat Action Plan for environmental quality management to be prepared according to section 37, the local official in the locality designated as the pollution control area pursuant to section 59, shall prepare and submit an action plan for reduction and eradication of pollution in such area to the Changwat Governor in order to incorporate such plan into the Changwat Action Plan for environment quality management.

In preparing the action plan for reduction and eradication of pollution, steps shall be taken as follows

(1) to survey and collect data concerning point sources of pollution located within the limits of that pollution control area.

(2) to make an inventory showing the number, type and size of point sources of pollution under survey and collection of data according to (1) above.

(3) to study, analyze and assess the state of pollution, as well as the scope, nature, severity of the problem and impacts on environmental quality in order to specify suitable and necessary measures for mitigation and eradication of pollution in that pollution control area.

The pollution control official shall give advice and assistance to the local official necessary for the preparation of the action plan to reduce and eradicate pollution according to the first and second paragraphs.

Section 61 The action plan for reduction and eradication of pollution in the pollution control area under section 60 shall propose the estimation and request for government budget and Fund allocations for construction or operation of the central wastewater treatment plant or the central waste disposal facility necessary to reduce and eradicate pollution in that pollution control area.

Section 62 In case it is necessary to acquire a piece of land to be used as the site of the central wastewater treatment or central waste disposal facility for any pollution control area but State owned land is not available, steps shall be taken to select and acquire land for sighting purpose. If there are expenses, the estimate and request for government budget and Fund allocation shall be made in the Changwat Action Plan.

If it is unable to proceed under the first paragraph, suitable land shall be selected and proposed to the Minister in order to take steps to expropriate such land in accordance with the law on expropriation of immovable property.

Section 63 The Changwat Governor shall supervise and oversee the local official's actions under section 59. If no action is taken by the local official within a reasonable time, the Changwat Governor shall have the power to take action on behalf of the local authority upon notification to such local authority and the National Environment Board.

Part 4
Air and Noise Pollution

Section 64 Usable vehicle shall conform to the emission standards prescribed for such vehicle pursuant to section 55.

Section 65 If it is found that the use of any vehicle is in violation of section 64, the competent official shall have the power to prohibit the use of such vehicle permanently or until it will have been modified or improved to meet the emission standard requirements prescribed pursuant to section 55.

Section 66 In issuing the order prohibiting to use of vehicle according to section 65, the competent official shall make the sign clearly shown by the words "Use Prohibited Permanently" or "Use Prohibited temporarily" or any other sign, known and understood by the general public to have the same meaning, on any part of such vehicle.

The making or removal of the sign under the first paragraph, or the use of vehicle while the said sign is on, shall be in accordance with the rules, methods and conditions specified in the ministerial regulation.

Section 67 In performing his duty under section 65, the competent official has the power to stop and inspect the vehicle, enter into the vehicle or to do any act necessary to check and test the engine and equipment of such vehicle.

Section 68 The Minister shall, with the advice of the Pollution Control Committee, have the power to publish notification in the Government Gazette specifying the types of point sources of pollution that shall be controlled in regard to the emission of polluted air, ray, or other pollutants, in the form of smoke, fume, gas, soot, dust, ash, particle or any other form of air pollutant, to the atmosphere, in conformity with the emission standards prescribed under section 55, or standards prescribed by any government agency by virtue of the other law which remain in force according to section 56, or standards set by the Changwat Governor in special case for the pollution control area according to section 58.

The owner or possessor of the point source of pollution under the first paragraph has the duty to install or bring into operation an on-site facility for air pollution control, equipment or other instrument as determined by the pollution control official in order to control, dispose, reduce or eliminate pollutants which may affect the air quality, unless such facility, equipment or instrument has already been in place and still in a working condition upon the inspection and test by the pollution control official. For the purpose of this section, the pollution control official may also require that the operation of such facility, equipment or instrument be controlled by the Monitoring Control Operator.

The provisions of the first and second paragraphs shall apply *mutatis mutandis* to the point source of pollution which emit or generate noise or vibration in excess of the emission standards set pursuant to section 55, or the standards set by any government agency by virtue the other law which remain in force according to section 56, or the standards set by the Changwat Governor in special case for the pollution control area according to section 58.

Part 5
Water Pollution

Section 69 The Minister shall, with the advice of the Pollution Control Committee, have the power to publish notification in the Government Gazette specifying the types of point sources of pollution that shall be controlled in regard to the discharge of wastewaters or wastes into public water sources or into the environment outside the limits of such point sources, in conformity with the effluent standards set pursuant to section 55, or the standards set by any government agency by virtue of the other law which remain in force according to section 56, or the standards set by the Changwat Governor in special case for the pollution control area according to section 58.

Section 70 The owner or possessor of the point source of pollution under section 69 has the duty to construct, install or bring into operation an on-site facility for wastewater treatment or waste disposal as determined by the pollution control official. For this purpose, the pollution control official may also require that such owner or possessor commission a Monitoring Control Operator to control the wastewater treatment or waste disposal facility that shall be constructed, installed or brought into operation accordingly.

If any point source of pollution has had an on-site facility for wastewater treatment or waste disposal before the date of notification of the Minister under section 69, the owner or possessor of such point source of pollution shall inform the pollution control official to check the functioning system of the

facility. If its capability to treat wastewaters or dispose of wastes fails to meet the applicable standards, the owner or possessor has the duty to modify or improve it in conformity with the pollution control official's directions.

Section 71 In any pollution control area or locality where a central wastewater treatment plant or a central waste disposal facility has been brought into operation by the administration concerned, the owner or possessor of the point source of pollution according to section 70, first paragraph, who has not yet constructed, installed or brought into operation the on-site facility for wastewater treatment or waste disposal according to the prescription of the pollution control official, or may not want to construct or make arrangements for such a system, shall have the duty to send the wastewaters or wastes generated by his activities to the central wastewater treatment plant or central waste disposal facility in the pollution control area or in that locality for treatment or disposal and shall have the duty to pay the service fees at the rates fixed by virtue of this Act or the other related laws.

Section 72 In any pollution control area or locality where the central waste water treatment plant or central waste disposal facility has been brought into operation by the administration concerned, the owner or possessor of any point source of pollution, except those under section 69, shall have the duty to send wastewaters or wastes from his source of pollution to the central waste water treatment plant or the central waste disposal facility in that pollution control area or locality for treatment or disposal and shall have the duty to pay service fees at the rates fixed by virtue of this Act or the other related laws, except such point source of pollution has already had its own wastewater treatment or waste disposal facility which is capable to meet the standards prescribed under this Act.

Section 73 No person shall be employed as a Monitoring Control Operator or as a Service Contractor, who renders for hire the services of wastewater treatment or waste disposal, without obtaining the license from the local official.

Application and issuance of license, qualifications of the applicant, control of the licensee's performance, renewal of license, issuance of certificate in lieu of the license, suspension or revocation of the license and fee payments for the application and issuance of license shall be in accordance with the rules, procedures and conditions stipulated by ministerial regulation.

The person who has obtained a license to be a Service Contractor shall also be deemed to have obtained a license to be a Monitoring Control Operator.

In rendering the services of wastewater treatment or waste disposal by the Service Contractor according to the first paragraph, the service charges shall not exceed the rates fixed by the ministerial regulation.

Section 74 In any pollution control area or locality where the central wastewater treatment or central waste disposal facility of the public service is yet to be put into operation, but there is nonetheless a Service Contractor who is licensed to render such services within that area, the owner or possessor of the point source of pollution according to section 70 and section 71 shall be required to send the wastewaters or wastes from his point source for treatment or disposal by such Service Contractor in accordance with the rules, regulations, methods and conditions prescribed by the local official, with the advice of the pollution control official.

Section 75 In any pollution control area or locality where the central wastewater treatment or central waste disposal facility is yet to be put into service by the government and there is no licensed Service Contractor rendering services therein, the local official may, with the advice of the pollution control official, determine a temporary method necessary for the treatment of wastewaters or disposal of wastes from point sources of pollution under section 70 and section 71 until the central wastewater treatment or central waste disposal facility will have been constructed, installed and put into operation within such pollution control area or locality.

The temporary method for wastewater treatment or waste disposal according to the first paragraph shall mean to include the collection, transport or conveyance of wastewaters or wastes by whatever appropriate means to be treated or disposed by the central wastewater treatment plant or central waste disposal facility of the government in the other area; or to allow the licensed Service Contractor rendering services in the other area to render the same services in that pollution control area or locality temporarily; or to allow such licensed Service Contractor to collect and transport wastewaters or wastes to treat or dispose by his own wastewater treatment or waste disposal facility located outside that pollution control area or locality.

Section 76 Wastewaters treated by either the central wastewaters treatment plant of the government or by the wastewater treatment facility of the Service Contractor must also have the properties which meet the requirements of the effluent standards prescribed by virtue of section 55, or the standards prescribed by virtue of the other law which remain in force according to section 56, or the standards set by the Changwat Governor in special case for the pollution control area according to section 58.

Section 77 The government agency or the local authority which makes provision for the services of central wastewater treatment or central waste disposal facilities by using government budget, or revenues of the local authority, and Fund allocations under this Act shall be responsible for the management and control of such facilities. In this respect, the responsible agency or local authority may employ a licensed Service Contractor under this Act to manage and control the operation of such facilities.

Regulations, rules and methods for conveyance, collection and transport of wastewaters or wastes from the point sources of pollution to the central wastewater treatment plant or central waste disposal facility as well as prescriptions, prohibitions, restrictions and other conditions for discharging and draining of wastewaters or wastes from factories and other point sources of pollution under section 72 into the systems of central wastewater treatment or central waste disposal facilities shall be prescribed by the ministerial regulation.

Part 6
Other Pollution and Hazardous Waste

Section 78 The collection, transport and other arrangements for the treatment and disposal of garbage and other solid wastes; the prevention and control of pollution from mining both on land and in the sea; the prevention and control of pollution from the exploration and drilling for oil, natural gas and all kinds of hydrocarbon both on land and in the sea; and the prevention and control of pollution resulting or originated from the discharge of oil and the dumping of wastes and other matters from sea-going vessels, tankers, and other types of vessel, shall be in accordance with the governing laws related thereto.

Section 79 In case there is no specific law applicable thereto, the Minister shall, with the advice of the Pollution Control Committee, have the power to issue ministerial regulation specifying the types and categories of hazardous wastes generated from the production and usage of chemicals or hazardous substances in the production process of industry, agriculture, sanitation and other activities which shall be brought under control. For this purpose, rules, regulations, measures and methods must also be prescribed for the control of collection, storage, safety measures, transportation, import into the Kingdom, export out of the Kingdom, and for proper and technically sound management, treatment and disposal of such hazardous wastes.

Part 7
Monitoring, Inspection and Control

Section 80 The owner or possessor of the point source of pollution, required by virtue of section 68 or section 70, to have his own facility for treatment of polluted air, equipment or instrument for control of the discharge of polluted air or other pollutants or the wastewater treatment or waste disposal facility, shall have the duty to collect statistics and data showing the daily functioning of the said facility or equipment and instrument, and make detailed notes thereof to be kept as recorded evidence at the site of that point source of pollution, and shall submit report summarizing the functioning results of the facility, equipment or instrument to the local official of the locality where such point source is situate at least once a month.

The collection of statistics and data, the making of notes and reports shall be in accordance with the rules, procedures, methods and format specified by ministerial regulation.

In case the facility for treatment of polluted air, wastewaters or waste disposal or equipment and instrument indicated in the first paragraph requires a Monitoring Control Operator as determined by the pollution control official, the Monitoring Control Operator shall have the duty to act under the first paragraph on behalf of the owner or possessor.

The Service Contractor licensed to render wastewater treatment or waste disposal services shall have the duty to do the same as the owner or possessor of the point source of pollution is required under the first paragraph.

Section 81 The local official shall gather the reports received according to section 80 and send them to the pollution control official, who has jurisdiction over that locality, on a regular basis at least once a month. In doing so, the local official may make comments for consideration of the pollution control official.

Section 82 In order to perform his functions under this Act, the pollution control official is empowered as follows:

(1) To enter into the building, place and site of the factory or point source of pollution or the site of wastewater treatment or waste disposal facility which belongs to any person, between the sun rise and sun set or during the working hours, to inspect the functioning process of wastewater treatment or waste disposal facility, air pollution control system or equipment and other instrument for the control of polluted air or other pollutants, as well as to examine the notes, statistics or data on the functioning of the said facility, equipment and instrument, or when there is a reasonable suspicion that there is a non-compliance with this Act.

(2) To issue an order in writing directing the owner or possessor, the Monitoring Control Operator, or the licensed Service Contractor rendering the services of wastewater treatment or waste disposal, to correct, change, improve or repair the air pollution control, wastewater treatment or waste disposal facility or other equipment and instrument for the control of polluted air or other pollutants. If however, the point source of pollution is a factory, the official under the law on industrial plants is to be notified to take action within his power and duty. If such official fails to do so, the pollution control official shall have the power to take action in accordance with this Act.

(3) To issue a written order directing the owner or possessor of the point source of pollution which is not a factory to pay penalties as provided under section 90, section 91 or section 92. If the point source of pollution is a factory the official under the law on industrial plants shall be notified to order the owner or possessor of such factory to pay the penalties and, in doing so, such official under the law on industrial plants shall be deemed to be the pollution control official under this Act. If, however, such official fails to issue the penalty order within a reasonable time, the pollution control official shall then have the power to issue the order directing the owner or possessor of such factory to pay the penalties.

(4) To issue a written order directing the Service Contractor licensed to render the services of wastewater treatment or waste disposal to stop or shut down his services, or revoking his license in case such Service Contractor violates or does not comply with this Act, or any ministerial regulation, local ordinance, rule, notification or condition issued or stipulated by virtue of this Act, or does not comply with the order of the pollution control official issued by virtue of this Act.

(5) To issue a written order suspending the Monitoring Control Operator under section 68 or section 70 in case such Monitoring Control Operator violates or does not comply with this Act, or any ministerial regulation, local ordinance, rule, notification, or condition issued or stipulated by virtue of this Act, or does not comply with the order of the pollution control official issued by virtue of this Act.

Section 83 In case it is deemed reasonable in the interest of co-ordination of action among agencies concerned, the pollution control official may:

(1) Recommend the official who has the legal power to control the point source of pollution, to close down its operation, to suspend or revoke the license of its owner or operator, or to bar its use or utilization in any way, especially in connection with the point source of pollution under section 68, section 69 or section 74 which has no intention to treat the polluted air, wastewaters or other wastes and illegally discharges the untreated wastes into the environment outside the limits of its site and premise.

(2) Recommend the local official to take legal action against the owner or possessor of the point source of pollution under section 71 or section 72 in order to coerce him to send wastewaters or wastes to be treated or disposed in accordance with this Act.

(3) Give advice and suggestions to the local official or the government agency concerned in connection with the operation and maintenance of the central wastewater treatment plant or the central waste disposal facility under the responsibility of such local official or government agency.

Section 84 In the performance of duty under this Act, the competent official or the pollution control official must produce his identity card at the request of the person concerned.

The identity card of the competent official and pollution control official shall be in such a form as prescribed in the ministerial regulation.

Section 85 The owner or occupier of premises, vehicles or any person concerned shall facilitate the performance of duty under this Act by the competent official or the pollution control official who shall be official under the Penal Code.

Section 86 The performance of duty by the competent official under section 50, first paragraph, or section 65 and the performance of duty by the pollution control official under section 82 (1) shall be done in the presence of the owner or occupier of the premise or vehicles; if such person cannot be found, it shall be done in the presence of at least two other persons requested by the competent official or the pollution control official to attend as witnesses.

Section 87 The owner or possessor of the point source of pollution, the Service Contractor licensed to render services of wastewater treatment or waste disposal, the Monitoring Control Operator or any other person who is not satisfied with the order of the pollution control official under section 82 (2), (3), (4) or (5), is entitled to challenge such order by petition to the Pollution Control Committee within thirty days form the date of receiving the order of the pollution control official.

If the petitioner does not agree with the decision of the Pollution Control Committee, he shall appeal to the Minister within thirty days from the date of receiving notification of the Pollution Control Committee's decision.

The decision of the Minister shall be final.

Part 8
Service Fee and Penalty

Section 88 In any pollution control area or locality where a central wastewater treatment plant of a central waste disposal facility has been constructed and brought into operation as a public utility service, funded by government budget or revenue of the local administration and money allocated from the Fund as provided in this Act, the National Environment Board shall, with the advice of the Pollution Control Committee, fix the rates of service fee to be applicable within the limits of each pollution control area or locality, being the site of and served by the operation of such facility.

The service fee rates fixed according to the foregoing first paragraph shall be notified and published in the Government Gazette.

Section 89 The rates of service fee fixed according to section 88 for treatment of wastewaters or for disposal of wastes emanated from point sources pursuant to section 71 and section 72 may be varied as appropriate.

The owner or possessor of the point source of pollution governed by the provision of section 72, in the category of domestic household, that can be classified as a small-scale user is entitled to be exempted from the payment of service fees in accordance with the rules and conditions stipulated by the National Environment Board, with the advice of the Pollution Control Committee.

Section 90 Any owner or possessor of point source of pollution who avowedly refrains from sending wastewaters or wastes to the central wastewater treatment plant or the central waste disposal facility as required by section 71 or section 72 and illegally discharges such wastewaters or wastes into the environment outside the limits of the site of the point source owned or possessed by him, or does send the wastewaters or wastes to the central wastewater treatment plant or the central waste disposal facility of the public service for treatment but fails or refuses to make payment for the service fees without being entitled to the exemption as provided by section 89, second paragraph, shall be liable to pay as a penalty four time as much the amount of service fee that he is liable to pay at the rate fixed in accordance with section 88 until the provision of this Act is observed by him.

Section 91 Any owner or possessor of the point source of pollution, required by section 70 to have an on-site facility for wastewater treatment or waste disposal, who illegally discharges wastewaters or wastes into the central wastewater treatment plant or the central waste disposal facility of the public service, shall be liable to pay as a daily penalty four time as much the amount of daily expenses for the normal operation

of his on-site facility for wastewater treatment or waste disposal throughout the duration of such illegal discharge and shall also be liable to pay damages if such illegal discharge has caused any damage or defection to the central wastewater treatment plant or the central waste disposal facility of the public service.

Section 92 Any owner or possessor of the point source of pollution subject to the requirements of section 68 or section 70, who refrains from using his on-site facilities or equipment for the control of air pollution, noise pollution and vibrations, or refrains from operating his on-site facilities for the treatment of wastewaters or disposal of wastes and illegally discharges such untreated wastewaters or wastes into the environment outside the limits of the site of the point source of pollution, shall be liable to pay as a daily penalty four time as much the amount of daily expenses for the normal operation of his facilities, equipment or process for wastewater treatment or waste disposal throughout the duration of such illegal discharge.

Section 93 The local authority or the competent official of the government agency responsible for the operation of the public wastewater treatment plant or waste disposal facility shall have the power and duty to collect service fees, penalties and claim for damages as provided in this Part, particularly in connection with the operation of the central wastewater treatment plant or the central waste disposal facility of the public service which is made available by such local authority or government agency.

The service fees and penalties collectable in accordance with the foregoing first paragraph shall be exempted from being remitted to the Treasury as government revenues, but shall be deducted and remitted to the Fund at the ratio specified by the Fund Committee, whereas the balance therefore shall be used as expenditures for operation and maintenance of the central wastewater treatment plant or the central waste disposal facility of the local authority or government agency which is responsible to collect such service fees and penalties.

Chapter V
Promotional Measures

Section 94 The owner or possessor of any point source of pollution, who has the duty according to this Act or other related laws to install an on-site facility for treatment of polluted air or wastewaters or for disposal of any other wastes, including the procurement of equipment, instrument, tools, appliances or materials necessary for control of pollution from such point source, or the Service Contractor licensed pursuant to this Act, is entitled to request for promotional supports and assistance from the government service in the following matters :

(1) Request for assistance regarding import duties for the import into the Kingdom of necessary machinery, equipment, instrument, tools, appliances or materials which are not available in the Kingdom.

(2) Application for permission to bring foreign experts or specialists into the country to carry out works concerning the installation, monitoring, control or operation of air pollution control systems, wastewater treatment works or waste disposal facilities in case qualified persons within the Kingdom are not available for recruitment and commissioning to supervise and control machinery, equipment, instrument or tools imported into the Kingdom pursuant to sub-section (1), including application for exemption of income tax that will incur from the performance of work as a supervisor of such person within the Kingdom.

The owner or possessor of the point source of pollution who has no legal duty as referred to in the foregoing first paragraph, but nonetheless wishes to install an on-site facility with his own equipment, instrument, tools or appliances for air pollution control, wastewater treatment or for disposal of other wastes emanated from his activities or business undertakings, is also entitled to request for promotional supports and assistance from the government service in accordance with the foregoing first paragraph.

Section 95 The request for promotional supports and assistance according to section 94 shall be made to the National Environment Board in accordance with the rules, procedures, methods and formats prescribed by ministerial regulation.

The National Environment Board shall consider and proceed with the request for promotional supports and assistance according to the foregoing first paragraph as it sees fit, taking into account the economic, financial and investment necessities of each individual applicant. In case it is considered appropriate to

give assistance to the applicant, the National Environment Board shall recommend the government agencies concerned to act within their powers and functions to render promotional supports and assistance to the applicant accordingly.

Chapter VI

Civil Liability

Section 96 If leakage or contamination caused by or originated from any point source of pollution is the cause of death, bodily harm or health injury of any person or has caused damage in any manner to the property of any private person or of the State, the owner or possessor of such point source shall be liable to pay compensation or damages therefore, regardless of whether such leakage or contamination is the result of a willful or negligent act of the owner or possessor thereof, except in case it can be proved that such pollution leakage or contamination is the result of

(1) Force majeure or war.

(2) An act done in compliance with the order of the Government or State authorities.

(3) An act or omission of the person who sustains injury or damage, or of any third party who is directly or indirectly responsible for the leakage or contamination.

The compensation or damages to which the owner or possessor of the point source of pollution shall be liable according to the foregoing first paragraph shall mean to include all the expenses actually incurred by the government service for the clean-up of pollution arisen from such incident of leakage or contamination.

Section 97 Any person who commits an unlawful act or omission by whatever means resulting in the destruction, loss or damage to natural resources owned by the State or belonging to the public domain shall be liable to make compensation to the State representing the total value of natural resources so destroyed, lost or damaged by such an unlawful act or omission.

Chapter VII

Penal Provisions

Section 98 Any person who violates or refuses to observe the order issued by virtue of section 8 or obstructs any act done in compliance with such order shall be punished by imprisonment not exceeding one year or fine not exceeding one hundred thousand baht, or both.

In case the person who violates or refuses to observe the order or obstructs any act done in compliance with such order is the person who has caused danger or damage arisen from pollution, such person shall be punished by imprisonment not exceeding five years or fine not exceeding five hundred thousand baht, or both.

Section 99 Any person who illegally encroaches upon, occupies, or enters into public land to act in any manner which results in the destruction, loss or damage to natural resources or treasures worthy of being conserved, or causes the occurrence of pollution having impact on the environment within the limits of environmentally protected area designated by virtue of section 43 shall be punished by imprisonment not exceeding five years or fine not exceeding five hundred thousand baht, or both.

Section 100 Any person who violates or refrains from observing the restrictions stipulated by ministerial regulation issued according to section 44 or by notification given by the Minister according to section 45 shall be punished by imprisonment not exceeding one year or fine not exceeding one hundred thousand baht, or both.

Section 101 Any person who spreads or disseminates false information about the danger from any point source of pollution with the intention to destroy its reputation or to undermine public trust on the lawful operation of its business or activity shall be punished by imprisonment not exceeding one year or fine not exceeding one hundred thousand baht, or both.

If the spread or dissemination of information according to the foregoing first paragraph is done by means of publication, announcement, advertisement or reports through newspaper, radio, television or other

forms of mass media, the person who commits such act shall be punished by imprisonment not exceeding five years or fine not exceeding five hundred thousand baht, or both.

Section 102 Any person who violates the order of competent official forbidding the use of vehicle according to section 65 shall be punished by fine not exceeding five thousand baht.

Section 103 Any person who refuses to observe the order given by competent official according to section 67 shall be punished by imprisonment not exceeding one month or fine not exceeding ten thousand baht, or both.

Section 104 Any owner or possessor of the point source of pollution who refrains from observing the provision of section 71, or any person who refrains from observing the provision of section 72, or the rules laid down by the local authority by virtue of section 74 or section 75, first paragraph, or the ministerial regulation issued by virtue of section 80 shall be punished by imprisonment not exceeding one year or fine not exceeding one hundred thousand baht, or both.

Section 105 Any person who renders services as a Monitoring Control Operator or as a Service Contractor for wastewater treatment or waste disposal without the license granted according to section 73 shall be punished by imprisonment not exceeding one year or fine not exceeding one hundred thousand baht, or both.

Section 106 Any owner or possessor of the point source of pollution or any Monitoring Control Operator or any Service Contractor rendering the services of wastewater treatment or waste disposal, who refrains from collecting statistics or data or from making notes or reports as required by Section 80 shall be punished by imprisonment not exceeding one month or fine not exceeding ten thousand baht, or both.

Section 107 Any Monitoring Control Operator or Service Contractor having the duty to make notes or reports according to this Act, who intentionally makes such notes or reports showing false

Information or statements shall be punished by imprisonment not exceeding one year or fine not exceeding one hundred thousand baht, or both.

Section 108 Any person who obstructs or refuses to comply with the order of the pollution control official given in the performance of his duty according to Section 82 (2) shall be punished by imprisonment not exceeding one month or fine not exceeding ten thousand baht, or both.

Section 109 Any Service Contractor rendering services for wastewater treatment or waste disposal ordered by the pollution control official to stop or close down his services pursuant to Section 82 (5), or any Monitoring Control Operator whose license has been revoked by the order of the pollution control official pursuant to Section 82 (6), who violates or refuses to comply with such order of the pollution control official or continues to carry on his service in violation of such order shall be punished by imprisonment not exceeding one year or fine not exceeding one hundred thousand baht, or both.

Section 110 Any owner or possessor of the point source of pollution who employs the person, whose license to be a Monitoring Control Operator has been revoked, to supervise and monitor the operation of air pollution control, wastewater treatment or waste disposal facility that he has the duty install and operate according to this Act, shall be punished by fine not exceeding fifty thousand baht.

Section 111 In case the offender who is liable to be punished according to this Act is a juristic person, the directors or managers of such juristic person, or any person who is responsible for the business operation of such juristic person, shall also be punishable by the same penalties prescribed by law for such offence, unless it can be proved that they have no part to play in the commission of such offence.

Interim Provisions

Section 112 In the period during which the National Environment Board is yet to be appointed in accordance with section 12 of this Act, the National Environment Board appointed prior to the date of effectiveness of this Act shall continue to hold office in order to perform its function until the new Board shall be appointed and take over the office.

Section 113 All ministerial regulations, rules, procedures, notifications or orders, issued by, virtue of the Enhancement and Conservation of National Environmental Quality Act, B.E. 2518 which remain in force on the date of effectiveness of this Act, shall continue to be effective, insofar as they are not in conflict

with or contrary to this Act, unless and until ministerial regulations, rules, procedures, notifications or orders will have been issued in accordance with this Act.

Section 114 The person, who has been holding a license as an eligible person to prepare reports concerning the study and measures for the prevention of and remedy for the adverse effect on environmental quality by virtue of the Enhancement and Conservation of National Environmental Quality Act, B.E. 2518, shall continue to be eligible to prepare the environmental impact assessment report provided by this Act, until such person is required by the Minister to apply for license in accordance with this Act.

Section 115 For all the reports concerning the study and measures for the prevention of and remedy for the adverse effect on environmental quality required for any project or activity pursuant to the Enhancement and Conservation of the National Environmental Quality Act, B.E. 2518, that have been filed prior to the date on which this Act shall come into effect and still pending review by the Office of National Environment Board, the review and approval of such reports shall be further proceeded with in accordance with the rules and procedures laid down by virtue of the Enhancement and Conservation of National Environmental Quality Act, B.E. 2518. For this purpose, the power and duty of the Office of National Environment Board in become the power and duty of the Office of Environmental Policy and Planning.

Countersigned by:

Anand Panyarachun

ANNEX IX. BASEL CONVENTION

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes And Their Disposal

BASEL CONVENTION ON THE CONTROL OF TRANSBOUNDARY MOVEMENTS OF HAZARDOUS WASTES AND THEIR DISPOSAL ADOPTED BY THE CONFERENCE OF THE PLENIPOTENTIARIES ON 22 MARCH 1989

ENTRY INTO FORCE MAY 1992

PREAMBLE[1]

The Parties to this Convention,

Aware of the risk of damage to human health and the environment caused by hazardous wastes and other wastes and the transboundary movement thereof,

Mindful of the growing threat to human health and the environment posed by the increased generation and complexity, and transboundary movement of hazardous wastes and other wastes,

Mindful also that the most effective way of protecting human health and the environment from the dangers posed by such wastes is the reduction of their generation to a minimum in terms of quantity and/or hazard potential,

Convinced that States should take necessary measures to ensure that the management of hazardous wastes and other wastes including their transboundary movement and disposal is consistent with the protection of human health and the environment whatever the place of disposal,

Noting that States should ensure that the generator should carry out duties with regard to the transport and disposal of hazardous wastes and other wastes in a manner that is consistent with the protection of the environment, whatever the place of disposal,

Fully recognizing that any State has the sovereign right to ban the entry or disposal of foreign hazardous wastes and other wastes in its territory,

[1]The Conference of the Parties adopted Decision III/1 at its third meeting to amend the Convention by adding a new preambular paragraph 7 bis. The amendment is not yet in force. Decision III/1 provides as follows:

"The Conference…

3 Decides to adopt the following amendment to the Convention:

'Insert new preambular paragraph 7 bis:

Recognizing that transboundary movements of hazardous wastes, especially to developing countries, have a high risk of not constituting an environmentally sound management of hazardous wastes as required by this Convention;…'"

Recognizing also the increasing desire for the prohibition of transboundary movements of hazardous wastes and their disposal in other States, especially developing countries,

Convinced that hazardous wastes and other wastes should, as far as is compatible with environmentally sound and efficient management, be disposed of in the State where they were generated,

Aware also that transboundary movements of such wastes from the State of their generation to any other State should be permitted only when conducted under conditions which do not endanger human health and the environment, and under conditions in conformity with the provisions of this Convention,

Considering that enhanced control of transboundary movement of hazardous wastes and other wastes will act as an incentive for their environmentally sound management and for the reduction of the volume of such transboundary movement,

Convinced that States should take measures for the proper exchange of information on and control of the transboundary movement of hazardous wastes and other wastes from and to those States,

Noting that a number of international and regional agreements have addressed the issue of protection and preservation of the environment with regard to the transit of dangerous goods,

Taking into account the Declaration of the United Nations Conference on the Human Environment (Stockholm, 1972), the Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Wastes adopted by the Governing Council of the United Nations Environment Programme (UNEP) by decision 14/30 of 17 June 1987, the Recommendations of the United Nations Committee of Experts on the Transport of Dangerous Goods (formulated in 1957 and updated biennially), relevant recommendations, declarations, instruments and regulations adopted within the United Nations system and the work and studies done within other international and regional organizations,

Mindful of the spirit, principles, aims and functions of the World Charter for Nature adopted by the General Assembly of the United Nations at its thirty-seventh session (1982) as the rule of ethics in respect of the protection of the human environment and the conservation of natural resources,

Affirming that States are responsible for the fulfilment of their international obligations concerning the protection of human health and protection and preservation of the environment, and are liable in accordance with international law,

Recognizing that in the case of a material breach of the provisions of this Convention or any protocol thereto the relevant international law of treaties shall apply,

Aware of the need to continue the development and implementation of environmentally sound low-waste technologies, recycling options, good house-keeping and management systems with a view to reducing to a minimum the generation of hazardous wastes and other wastes,

Aware also of the growing international concern about the need for stringent control of transboundary movement of hazardous wastes and other wastes, and of the need as far as possible to reduce such movement to a minimum,

Concerned about the problem of illegal transboundary traffic in hazardous wastes and other wastes,

Taking into account also the limited capabilities of the developing countries to manage hazardous wastes and other wastes,

Recognizing the need to promote the transfer of technology for the sound management of hazardous wastes and other wastes produced locally, particularly to the developing countries in

accordance with the spirit of the Cairo Guidelines and decision 14/16 of the Governing Council of UNEP on Promotion of the transfer of environmental protection technology,

Recognizing also that hazardous wastes and other wastes should be transported in accordance with relevant international conventions and recommendations,

Convinced also that the transboundary movement of hazardous wastes and other wastes should be permitted only when the transport and the ultimate disposal of such wastes is environmentally sound, and

Determined to protect, by strict control, human health and the environment against the adverse effects which may result from the generation and management of hazardous wastes and other wastes,

HAVE AGREED AS FOLLOWS:

Article 1

Scope of the Convention

1. The following wastes that are subject to transboundary movement shall be "hazardous wastes" for the purposes of this Convention:

(a) Wastes that belong to any category contained in Annex I, unless they do not possess any of the characteristics contained in Annex III; and

(b) Wastes that are not covered under paragraph (a) but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the Party of export, import or transit.

2. Wastes that belong to any category contained in Annex II that are subject to transboundary movement shall be "other wastes" for the purposes of this Convention.

3. Wastes which, as a result of being radioactive, are subject to other international control systems, including international instruments, applying specifically to radioactive materials, are excluded from the scope of this Convention.

4. Wastes which derive from the normal operations of a ship, the discharge of which is covered by another international instrument, are excluded from the scope of this Convention.

Article 2

Definitions

For the purposes of this Convention:

1. "Wastes" are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law;

2. "Management" means the collection, transport and disposal of hazardous wastes or other wastes, including after-care of disposal sites;

3. "Transboundary movement" means any movement of hazardous wastes or other wastes from an area under the national jurisdiction of one State to or through an area under the national jurisdiction of another State or to or through an area not under the national jurisdiction of any State, provided at least two States are involved in the movement;

4. "Disposal" means any operation specified in Annex IV to this Convention;

5. "Approved site or facility" means a site or facility for the disposal of hazardous wastes or other wastes which is authorized or permitted to operate for this purpose by a relevant authority of the State where the site or facility is located;

6. "Competent authority" means one governmental authority designated by a Party to be responsible, within such geographical areas as the Party may think fit, for receiving the notification of a transboundary movement of hazardous wastes or other wastes, and any information related to it, and for responding to such a notification, as provided in Article 6;

7. "Focal point" means the entity of a Party referred to in Article 5 responsible for receiving and submitting information as provided for in Articles 13 and 16;

8. "Environmentally sound management of hazardous wastes or other wastes" means taking all practicable steps to ensure that hazardous wastes or other wastes are managed in a manner which will protect human health and the environment against the adverse effects which may result from such wastes;

9. "Area under the national jurisdiction of a State" means any land, marine area or airspace within which a State exercises administrative and regulatory responsibility in accordance with international law in regard to the protection of human health or the environment;

10. "State of export" means a Party from which a transboundary movement of hazardous wastes or other wastes is planned to be initiated or is initiated;

11. "State of import" means a Party to which a transboundary movement of hazardous wastes or other wastes is planned or takes place for the purpose of disposal therein or for the purpose of loading prior to disposal in an area not under the national jurisdiction of any State;

12. "State of transit" means any State, other than the State of export or import, through which a movement of hazardous wastes or other wastes is planned or takes place;

13. "States concerned" means Parties which are States of export or import, or transit States, whether or not Parties;

14. "Person" means any natural or legal person;

15. "Exporter" means any person under the jurisdiction of the State of export who arranges for hazardous wastes or other wastes to be exported;

16. "Importer" means any person under the jurisdiction of the State of import who arranges for hazardous wastes or other wastes to be imported;

17. "Carrier" means any person who carries out the transport of hazardous wastes or other wastes;

18. "Generator" means any person whose activity produces hazardous wastes or other wastes or, if that person is not known, the person who is in possession and/or control of those wastes;

19. "Disposer" means any person to whom hazardous wastes or other wastes are shipped and who carries out the disposal of such wastes;

20. "Political and/or economic integration organization" means an organization constituted by sovereign States to which its member States have transferred competence in respect of matters governed by this Convention and which has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve, formally confirm or accede to it;

21. "Illegal traffic" means any transboundary movement of hazardous wastes or other wastes as specified in Article 9.

Article 3

National Definitions of Hazardous Wastes

1. Each Party shall, within six months of becoming a Party to this Convention, inform the Secretariat of the Convention of the wastes, other than those listed in Annexes I and II, considered or defined as hazardous under its national legislation and of any requirements concerning transboundary movement procedures applicable to such wastes.

2. Each Party shall subsequently inform the Secretariat of any significant changes to the information it has provided pursuant to paragraph 1.

3. The Secretariat shall forthwith inform all Parties of the information it has received pursuant to paragraphs 1 and 2.

4. Parties shall be responsible for making the information transmitted to them by the Secretariat under paragraph 3 available to their exporters.

Article 4[1]

General Obligations

1. (a) Parties exercising their right to prohibit the import of hazardous wastes or other wastes for disposal shall inform the other Parties of their decision pursuant to Article 13.

[1] The Conference of the Parties adopted Decision III/1 at its third meeting to amend the Convention by adding a new Article 4A. The amendment is not yet in force. Decision III/1 provides as follows:

"The Conference

…

3 Decides to adopt the following amendment to the Convention:

…
'Insert new Article 4A:

1. Each Party listed in Annex VII shall prohibit all transboundary movements of hazardous wastes which are destined for operations according to Annex IV A, to States not listed in Annex VII.
2. Each Party listed in Annex VII shall phase out by 31 December 1997, and prohibit as of that date, all transboundary movements of hazardous wastes under Article 1(1)(a) of the Convention which are destined for operations according to Annex IV B to States not listed in Annex VII. Such transboundary movement shall not be

prohibited unless the wastes in question are characterised as hazardous under the Convention.…'"

(b) Parties shall prohibit or shall not permit the export of hazardous wastes and other wastes to the Parties which have prohibited the import of such wastes, when notified pursuant to subparagraph (a) above.

(c) Parties shall prohibit or shall not permit the export of hazardous wastes and other wastes if the State of import does not consent in writing to the specific import, in the case where that State of import has not prohibited the import of such wastes.

2. Each Party shall take the appropriate measures to:

(a) Ensure that the generation of hazardous wastes and other wastes within it is reduced to a minimum, taking into account social, technological and economic aspects;

(b) Ensure the availability of adequate disposal facilities, for the environmentally sound management of hazardous wastes and other wastes, that shall be located, to the extent possible, within it, whatever the place of their disposal;

(c) Ensure that persons involved in the management of hazardous wastes or other wastes within it take such steps as are necessary to prevent pollution due to hazardous wastes and other wastes arising from such management and, if such pollution occurs, to minimize the consequences thereof for human health and the environment;

(d) Ensure that the transboundary movement of hazardous wastes and other wastes is reduced to the minimum consistent with the environmentally sound and efficient management of such wastes, and is conducted in a manner which will protect human health and the environment against the adverse effects which may result from such movement;

(e) Not allow the export of hazardous wastes or other wastes to a State or group of States belonging to an economic and/or political integration organization that are Parties, particularly developing countries, which have prohibited by their legislation all imports, or if it has reason to believe that the wastes in question will not be managed in an environmentally sound manner, according to criteria to be decided on by the Parties at their first meeting;

(f) Require that information about a proposed transboundary movement of hazardous wastes and other wastes be provided to the States concerned, according to Annex V A, to state clearly the effects of the proposed movement on human health and the environment;

(g) Prevent the import of hazardous wastes and other wastes if it has reason to believe that the wastes in question will not be managed in an environmentally sound manner;

(h) Co-operate in activities with other Parties and interested organizations, directly and through the Secretariat, including the dissemination of information on the transboundary movement of hazardous wastes and other wastes, in order to improve the environmentally sound management of such wastes and to achieve the prevention of illegal traffic.

3. The Parties consider that illegal traffic in hazardous wastes or other wastes is criminal.

4. Each Party shall take appropriate legal, administrative and other measures to implement and

enforce the provisions of this Convention, including measures to prevent and punish conduct in contravention of the Convention.

5. A Party shall not permit hazardous wastes or other wastes to be exported to a non-Party or to be imported from a non-Party.

6. The Parties agree not to allow the export of hazardous wastes or other wastes for disposal within the area south of 60° South latitude, whether or not such wastes are subject to transboundary movement.

7. Furthermore, each Party shall:

(a) Prohibit all persons under its national jurisdiction from transporting or disposing of hazardous wastes or other wastes unless such persons are authorized or allowed to perform such types of operations;

(b) Require that hazardous wastes and other wastes that are to be the subject of a transboundary movement be packaged, labelled, and transported in conformity with generally accepted and recognized international rules and standards in the field of packaging, labelling, and transport, and that due account is taken of relevant internationally recognized practices;

(c) Require that hazardous wastes and other wastes be accompanied by a movement document from the point at which a transboundary movement commences to the point of disposal.

8. Each Party shall require that hazardous wastes or other wastes, to be exported, are managed in an environmentally sound manner in the State of import or elsewhere. Technical guidelines for the environmentally sound management of wastes subject to this Convention shall be decided by the Parties at their first meeting.

9. Parties shall take the appropriate measures to ensure that the transboundary movement of hazardous wastes and other wastes only be allowed if:

(a) The State of export does not have the technical capacity and the necessary facilities, capacity or suitable disposal sites in order to dispose of the wastes in question in an environmentally sound and efficient manner; or

(b) The wastes in question are required as a raw material for recycling or recovery industries in the State of import; or

(c) The transboundary movement in question is in accordance with other criteria to be decided by the Parties, provided those criteria do not differ from the objectives of this Convention.

10. The obligation under this Convention of States in which hazardous wastes and other wastes are generated to require that those wastes are managed in an environmentally sound manner may not under any circumstances be transferred to the States of import or transit.

11. Nothing in this Convention shall prevent a Party from imposing additional requirements that are consistent with the provisions of this Convention, and are in accordance with the rules of international law, in order better to protect human health and the environment.

12. Nothing in this Convention shall affect in any way the sovereignty of States over their

territorial sea established in accordance with international law, and the sovereign rights and the jurisdiction which States have in their exclusive economic zones and their continental shelves in accordance with international law, and the exercise by ships and aircraft of all States of navigational rights and freedoms as provided for in international law and as reflected in relevant international instruments.

13. Parties shall undertake to review periodically the possibilities for the reduction of the amount and/or the pollution potential of hazardous wastes and other wastes which are exported to other States, in particular to developing countries.

Article 5

Designation of Competent Authorities and Focal Point

To facilitate the implementation of this Convention, the Parties shall:

1. Designate or establish one or more competent authorities and one focal point. One competent authority shall be designated to receive the notification in case of a State of transit.

2. Inform the Secretariat, within three months of the date of the entry into force of this Convention for them, which agencies they have designated as their focal point and their competent authorities.

3. Inform the Secretariat, within one month of the date of decision, of any changes regarding the designation made by them under paragraph 2 above.

Article 6

Transboundary Movement between Parties

1. The State of export shall notify, or shall require the generator or exporter to notify, in writing, through the channel of the competent authority of the State of export, the competent authority of the States concerned of any proposed transboundary movement of hazardous wastes or other wastes. Such notification shall contain the declarations and information specified in Annex V A, written in a language acceptable to the State of import. Only one notification needs to be sent to each State concerned.

2. The State of import shall respond to the notifier in writing, consenting to the movement with or without conditions, denying permission for the movement, or requesting additional information. A copy of the final response of the State of import shall be sent to the competent authorities of the States concerned which are Parties.

3. The State of export shall not allow the generator or exporter to commence the transboundary movement until it has received written confirmation that:

(a) The notifier has received the written consent of the State of import; and

(b) The notifier has received from the State of import confirmation of the existence of a contract between the exporter and the disposer specifying environmentally sound management of the wastes in question.

4. Each State of transit which is a Party shall promptly acknowledge to the notifier receipt of the

notification. It may subsequently respond to the notifier in writing, within 60 days, consenting to the movement with or without conditions, denying permission for the movement, or requesting additional information. The State of export shall not allow the transboundary movement to commence until it has received the written consent of the State of transit. However, if at any time a Party decides not to require prior written consent, either generally or under specific conditions, for transit transboundary movements of hazardous wastes or other wastes, or modifies its requirements in this respect, it shall forthwith inform the other Parties of its decision pursuant to Article 13. In this latter case, if no response is received by the State of export within 60 days of the receipt of a given notification by the State of transit, the State of export may allow the export to proceed through the State of transit.

5. In the case of a transboundary movement of wastes where the wastes are legally defined as or considered to be hazardous wastes only:

(a) By the State of export, the requirements of paragraph 9 of this Article that apply to the importer or disposer and the State of import shall apply mutatis mutandis to the exporter and State of export, respectively;

(b) By the State of import, or by the States of import and transit which are Parties, the requirements of paragraphs 1, 3, 4 and 6 of this Article that apply to the exporter and State of export shall apply mutatis mutandis to the importer or disposer and State of import, respectively; or

(c) By any State of transit which is a Party, the provisions of paragraph 4 shall apply to such State.

6. The State of export may, subject to the written consent of the States concerned, allow the generator or the exporter to use a general notification where hazardous wastes or other wastes having the same physical and chemical characteristics are shipped regularly to the same disposer via the same customs office of exit of the State of export via the same customs office of entry of the State of import, and, in the case of transit, via the same customs office of entry and exit of the State or States of transit.

7. The States concerned may make their written consent to the use of the general notification referred to in paragraph 6 subject to the supply of certain information, such as the exact quantities or periodical lists of hazardous wastes or other wastes to be shipped.

8. The general notification and written consent referred to in paragraphs 6 and 7 may cover multiple shipments of hazardous wastes or other wastes during a maximum period of 12 months.

9. The Parties shall require that each person who takes charge of a transboundary movement of hazardous wastes or other wastes sign the movement document either upon delivery or receipt of the wastes in question. They shall also require that the disposer inform both the exporter and the competent authority of the State of export of receipt by the disposer of the wastes in question and, in due course, of the completion of disposal as specified in the notification. If no such information is received within the State of export, the competent authority of the State of export or the exporter shall so notify the State of import.

10. The notification and response required by this Article shall be transmitted to the competent authority of the Parties concerned or to such governmental authority as may be appropriate in the case of non-Parties.

11. Any transboundary movement of hazardous wastes or other wastes shall be covered by

insurance, bond or other guarantee as may be required by the State of import or any State of transit which is a Party.

Article 7

Transboundary Movement from a Party through States which are not Parties

Paragraph 1 of Article 6 of the Convention shall apply mutatis mutandis to transboundary movement of hazardous wastes or other wastes from a Party through a State or States which are not Parties.

Article 8

Duty to Re-import

When a transboundary movement of hazardous wastes or other wastes to which the consent of the States concerned has been given, subject to the provisions of this Convention, cannot be completed in accordance with the terms of the contract, the State of export shall ensure that the wastes in question are taken back into the State of export, by the exporter, if alternative arrangements cannot be made for their disposal in an environmentally sound manner, within 90 days from the time that the importing State informed the State of export and the Secretariat, or such other period of time as the States concerned agree. To this end, the State of export and any Party of transit shall not oppose, hinder or prevent the return of those wastes to the State of export.

Article 9

Illegal Traffic

1. For the purpose of this Convention, any transboundary movement of hazardous wastes or other wastes:

(a) without notification pursuant to the provisions of this Convention to all States concerned; or

(b) without the consent pursuant to the provisions of this Convention of a State concerned; or

(c) with consent obtained from States concerned through falsification, misrepresentation or fraud; or

(d) that does not conform in a material way with the documents; or

(e) that results in deliberate disposal (e.g. dumping) of hazardous wastes or other wastes in contravention of this Convention and of general principles of international law, shall be deemed to be illegal traffic.

2. In case of a transboundary movement of hazardous wastes or other wastes deemed to be illegal traffic as the result of conduct on the part of the exporter or generator, the State of export shall ensure that the wastes in question are:

(a) taken back by the exporter or the generator or, if necessary, by itself into the State of export, or, if impracticable,

(b) are otherwise disposed of in accordance with the provisions of this Convention, within 30 days from the time the State of export has been informed about the illegal traffic or such other period of time as States concerned may agree. To this end, the Parties concerned shall not oppose, hinder or prevent the return of those wastes to the State of export.

3. In the case of a transboundary movement of hazardous wastes or other wastes deemed to be illegal traffic as the result of conduct on the part of the importer or disposer, the State of import shall ensure that the wastes in question are disposed of in an environmentally sound manner by the importer or disposer or, if necessary, by itself within 30 days from the time the illegal traffic has come to the attention of the State of import or such other period of time as the States concerned may agree. To this end, the Parties concerned shall co-operate, as necessary, in the disposal of the wastes in an environmentally sound manner.

4. In cases where the responsibility for the illegal traffic cannot be assigned either to the exporter or generator or to the importer or disposer, the Parties concerned or other Parties, as appropriate, shall ensure, through co-operation, that the wastes in question are disposed of as soon as possible in an environmentally sound manner either in the State of export or the State of import or elsewhere as appropriate.

5. Each Party shall introduce appropriate national/domestic legislation to prevent and punish illegal traffic. The Parties shall co-operate with a view to achieving the objects of this Article.

Article 10

International Co-operation

1. The Parties shall co-operate with each other in order to improve and achieve environmentally sound management of hazardous wastes and other wastes.

2. To this end, the Parties shall:

(a) Upon request, make available information, whether on a bilateral or multilateral basis, with a view to promoting the environmentally sound management of hazardous wastes and other wastes, including harmonization of technical standards and practices for the adequate management of hazardous wastes and other wastes;

(b) Co-operate in monitoring the effects of the management of hazardous wastes on human health and the environment;

(c) Co-operate, subject to their national laws, regulations and policies, in the development and implementation of new environmentally sound low-waste technologies and the improvement of existing technologies with a view to eliminating, as far as practicable, the generation of hazardous wastes and other wastes and achieving more effective and efficient methods of ensuring their management in an environmentally sound manner, including the study of the economic, social and environmental effects of the adoption of such new or improved technologies;

(d) Co-operate actively, subject to their national laws, regulations and policies, in the

transfer of technology and management systems related to the environmentally sound management of hazardous wastes and other wastes. They shall also co-operate in developing the technical capacity among Parties, especially those which may need and request technical assistance in this field;

(e) Co-operate in developing appropriate technical guidelines and/or codes of practice.

3. The Parties shall employ appropriate means to co-operate in order to assist developing countries in the implementation of subparagraphs a, b, c and d of paragraph 2 of Article 4.

4. Taking into account the needs of developing countries, co-operation between Parties and the competent international organizations is encouraged to promote, inter alia, public awareness, the development of sound management of hazardous wastes and other wastes and the adoption of new low-waste technologies.

Article 11

Bilateral, Multilateral and Regional Agreements

1. Notwithstanding the provisions of Article 4 paragraph 5, Parties may enter into bilateral, multilateral, or regional agreements or arrangements regarding transboundary movement of hazardous wastes or other wastes with Parties or non-Parties provided that such agreements or arrangements do not derogate from the environmentally sound management of hazardous wastes and other wastes as required by this Convention. These agreements or arrangements shall stipulate provisions which are not less environmentally sound than those provided for by this Convention in particular taking into account the interests of developing countries.

2. Parties shall notify the Secretariat of any bilateral, multilateral or regional agreements or arrangements referred to in paragraph 1 and those which they have entered into prior to the entry into force of this Convention for them, for the purpose of controlling transboundary movements of hazardous wastes and other wastes which take place entirely among the Parties to such agreements. The provisions of this Convention shall not affect transboundary movements which take place pursuant to such agreements provided that such agreements are compatible with the environmentally sound management of hazardous wastes and other wastes as required by this Convention.

Article 12

Consultations on Liability

The Parties shall co-operate with a view to adopting, as soon as practicable, a protocol setting out appropriate rules and procedures in the field of liability and compensation for damage resulting from the transboundary movement and disposal of hazardous wastes and other wastes.

Article 13

Transmission of Information

1. The Parties shall, whenever it comes to their knowledge, ensure that, in the case of an accident occurring during the transboundary movement of hazardous wastes or other wastes or their disposal, which are likely to present risks to human health and the environment in other States,

those States are immediately informed.

2. The Parties shall inform each other, through the Secretariat, of:

(a) Changes regarding the designation of competent authorities and/or focal points, pursuant to Article 5;

(b) Changes in their national definition of hazardous wastes, pursuant to Article 3; nd, as soon as possible,

(c) Decisions made by them not to consent totally or partially to the import of hazardous wastes or other wastes for disposal within the area under their national jurisdiction;

(d) Decisions taken by them to limit or ban the export of hazardous wastes or other wastes;

(e) Any other information required pursuant to paragraph 4 of this Article.

3. The Parties, consistent with national laws and regulations, shall transmit, through the Secretariat, to the Conference of the Parties established under Article 15, before the end of each calendar year, a report on the previous calendar year, containing the following information:

(a) Competent authorities and focal points that have been designated by them pursuant to Article 5;

(b) Information regarding transboundary movements of hazardous wastes or other wastes in which they have been involved, including:

(i) The amount of hazardous wastes and other wastes exported, their category, characteristics, destination, any transit country and disposal method as stated on the response to notification;

(ii) The amount of hazardous wastes and other wastes imported, their category, characteristics, origin, and disposal methods;

(iii) Disposals which did not proceed as intended;

(iv) Efforts to achieve a reduction of the amount of hazardous wastes or other wastes subject to transboundary movement;

(c) Information on the measures adopted by them in implementation of this Convention;

(d) Information on available qualified statistics which have been compiled by them on the effects on human health and the environment of the generation, transportation and disposal of hazardous wastes or other wastes;

(e) Information concerning bilateral, multilateral and regional agreements and arrangements entered into pursuant to Article 11 of this Convention;

(f) Information on accidents occurring during the transboundary movement and disposal of hazardous wastes and other wastes and on the measures undertaken to deal with them;

(g) Information on disposal options operated within the area of their national jurisdiction;

(h) Information on measures undertaken for development of technologies for the

reduction and/or elimination of production of hazardous wastes and other wastes; and

(i) Such other matters as the Conference of the Parties shall deem relevant.

4. The Parties, consistent with national laws and regulations, shall ensure that copies of each notification concerning any given transboundary movement of hazardous wastes or other wastes, and the response to it, are sent to the Secretariat when a Party considers that its environment may be affected by that transboundary movement has requested that this should be done.

Article 14

Financial Aspects

1. The Parties agree that, according to the specific needs of different regions and subregions, regional or sub-regional centres for training and technology transfers regarding the management of hazardous wastes and other wastes and the minimization of their generation should be established. The Parties shall decide on the establishment of appropriate funding mechanisms of a voluntary nature.

2. The Parties shall consider the establishment of a revolving fund to assist on an interim basis in case of emergency situations to minimize damage from accidents arising from transboundary movements of hazardous wastes and other wastes or during the disposal of those wastes.

Article 15

Conference of the Parties

1. A Conference of the Parties is hereby established. The first meeting of the Conference of the Parties shall be convened by the Executive Director of UNEP not later than one year after the entry into force of this Convention. Thereafter, ordinary meetings of the Conference of the Parties shall be held at regular intervals to be determined by the Conference at its first meeting.

2. Extraordinary meetings of the Conference of the Parties shall be held at such other times as may be deemed necessary by the Conference, or at the written request of any Party, provided that, within six months of the request being communicated to them by the Secretariat, it is supported by at least one third of the Parties.

3. The Conference of the Parties shall by consensus agree upon and adopt rules of procedure for itself and for any subsidiary body it may establish, as well as financial rules to determine in particular the financial participation of the Parties under this Convention.

4. The Parties at their first meeting shall consider any additional measures needed to assist them in fulfilling their responsibilities with respect to the protection and the preservation of the marine environment in the context of this Convention.

5. The Conference of the Parties shall keep under continuous review and evaluation the effective implementation of this Convention, and, in addition, shall:

(a) Promote the harmonization of appropriate policies, strategies and measures for minimizing harm to human health and the environment by hazardous wastes and other wastes;

(b) Consider and adopt, as required, amendments to this Convention and its annexes, taking into consideration, inter alia, available scientific, technical, economic and environmental information;

(c) Consider and undertake any additional action that may be required for the achievement of the purposes of this Convention in the light of experience gained in its operation and in the operation of the agreements and arrangements envisaged in Article 11;

(d) Consider and adopt protocols as required; and

(e) Establish such subsidiary bodies as are deemed necessary for the implementation of this Convention.

6. The United Nations, its specialized agencies, as well as any State not Party to this Convention, may be represented as observers at meetings of the Conference of the Parties. Any other body or agency, whether national or international, governmental or non-governmental, qualified in fields relating to hazardous wastes or other wastes which has informed the Secretariat of its wish to be represented as an observer at a meeting of the Conference of the Parties, may be admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the Conference of the Parties.

7. The Conference of the Parties shall undertake three years after the entry into force of this Convention, and at least every six years thereafter, an evaluation of its effectiveness and, if deemed necessary, to consider the adoption of a complete or partial ban of transboundary movements of hazardous wastes and other wastes in light of the latest scientific, environmental, technical and economic information.

Article 16

Secretariat

1. The functions of the Secretariat shall be:

(a) To arrange for and service meetings provided for in Articles 15 and 17;

(b) To prepare and transmit reports based upon information received in accordance with Articles 3, 4, 6, 11 and 13 as well as upon information derived from meetings of subsidiary bodies established under Article 15 as well as upon, as appropriate, information provided by relevant intergovernmental and non-governmental entities;

(c) To prepare reports on its activities carried out in implementation of its functions under this Convention and present them to the Conference of the Parties;

(d) To ensure the necessary coordination with relevant international bodies, and in particular to enter into such administrative and contractual arrangements as may be required for the effective discharge of its function;

(e) To communicate with focal points and competent authorities established by the Parties in accordance with Article 5 of this Convention;

(f) To compile information concerning authorized national sites and facilities of Parties available for the disposal of their hazardous wastes and other wastes and to circulate this

information among Parties;

(g) To receive and convey information from and to Parties on:

- sources of technical assistance and training;
- available technical and scientific know-how;
- sources of advice and expertise; and
- availability of resources

with a view to assisting them, upon request, in such areas as:

- the handling of the notification system of this Convention;
- the management of hazardous wastes and other wastes;
- environmentally sound technologies relating to hazardous wastes and other wastes; such as low- and non-waste technology;
- the assessment of disposal capabilities and sites;
- the monitoring of hazardous wastes and other wastes; and
- emergency responses;

(h) To provide Parties, upon request, with information on consultants or consulting firms having the necessary technical competence in the field, which can assist them to examine a notification for a transboundary movement, the concurrence of a shipment of hazardous wastes or other wastes with the relevant notification, and/or the fact that the proposed disposal facilities for hazardous wastes or other wastes are environmentally sound, when they have reason to believe that the wastes in question will not be managed in an environmentally sound manner. Any such examination would not be at the expense of the Secretariat;

(i) To assist Parties upon request in their identification of cases of illegal traffic and to circulate immediately to the Parties concerned any information it has received regarding illegal traffic;

(j) To co-operate with Parties and with relevant and competent international organizations and agencies in the provision of experts and equipment for the purpose of rapid assistance to States in the event of an emergency situation; and

(k) To perform such other functions relevant to the purposes of this Convention as may be determined by the Conference of the Parties.

2. The secretariat functions will be carried out on an interim basis by UNEP until the completion of the first meeting of the Conference of the Parties held pursuant to Article 15.

3. At its first meeting, the Conference of the Parties shall designate the Secretariat from among those existing competent intergovernmental organizations which have signified their willingness to carry out the secretariat functions under this Convention. At this meeting, the Conference of the Parties shall also evaluate the implementation by the interim Secretariat of the functions assigned to it, in particular under paragraph 1 above, and decide upon the structures appropriate for those functions.

Article 17

Amendment of the Convention

1. Any Party may propose amendments to this Convention and any Party to a protocol may propose amendments to that protocol. Such amendments shall take due account, inter alia, of relevant scientific and technical considerations.

2. Amendments to this Convention shall be adopted at a meeting of the Conference of the Parties. Amendments to any protocol shall be adopted at a meeting of the Parties to the protocol in question. The text of any proposed amendment to this Convention or to any protocol, except as may otherwise be provided in such protocol, shall be communicated to the Parties by the Secretariat at least six months before the meeting at which it is proposed for adoption. The Secretariat shall also communicate proposed amendments to the Signatories to this Convention for information.

3. The Parties shall make every effort to reach agreement on any proposed amendment to this Convention by consensus. If all efforts at consensus have been exhausted, and no agreement reached, the amendment shall as a last resort be adopted by a three-fourths majority vote of the Parties present and voting at the meeting, and shall be submitted by the Depositary to all Parties for ratification, approval, formal confirmation or acceptance.

4. The procedure mentioned in paragraph 3 above shall apply to amendments to any protocol, except that a two-thirds majority of the Parties to that protocol present and voting at the meeting shall suffice for their adoption.

5. Instruments of ratification, approval, formal confirmation or acceptance of amendments shall be deposited with the Depositary. Amendments adopted in accordance with paragraphs 3 or 4 above shall enter into force between Parties having accepted them on the ninetieth day after the receipt by the Depositary of their instrument of ratification, approval, formal confirmation or acceptance by at least three-fourths of the Parties who accepted them or by at least two thirds of the Parties to the protocol concerned who accepted them, except as may otherwise be provided in such protocol. The amendments shall enter into force for any other Party on the ninetieth day after that Party deposits its instrument of ratification, approval, formal confirmation or acceptance of the amendments.

6. For the purpose of this Article, "Parties present and voting" means Parties present and casting an affirmative or negative vote.

Article 18

Adoption and Amendment of Annexes

1. The annexes to this Convention or to any protocol shall form an integral part of this Convention or of such protocol, as the case may be and, unless expressly provided otherwise, a reference to this Convention or its protocols constitutes at the same time a reference to any annexes thereto. Such annexes shall be restricted to scientific, technical and administrative matters.

2. Except as may be otherwise provided in any protocol with respect to its annexes, the following procedure shall apply to the proposal, adoption and entry into force of additional annexes to this Convention or of annexes to a protocol:

(a) Annexes to this Convention and its protocols shall be proposed and adopted according to the procedure laid down in Article 17, paragraphs 2, 3 and 4;

(b) Any Party that is unable to accept an additional annex to this Convention or an annex to any protocol to which it is party shall so notify the Depositary, in writing, within six months from the date of the communication of the adoption by the Depositary. The Depositary shall without delay notify all Parties of any such notification received. A Party may at any time substitute an acceptance for a previous declaration of objection and the annexes shall thereupon enter into force for that Party;

(c) On the expiry of six months from the date of the circulation of the communication by the Depositary, the annex shall become effective for all Parties to this Convention or to any protocol concerned, which have not submitted a notification in accordance with the provision of subparagraph (b) above.

3. The proposal, adoption and entry into force of amendments to annexes to this Convention or to any protocol shall be subject to the same procedure as for the proposal, adoption and entry into force of annexes to the Convention or annexes to a protocol. Annexes and amendments thereto shall take due account, inter alia, of relevant scientific and technical considerations.

4. If an additional annex or an amendment to an annex involves an amendment to this Convention or to any protocol, the additional annex or amended annex shall not enter into force until such time the amendment to this Convention or to the protocol enters into force.

Article 19

Verification

Any Party which has reason to believe that another Party is acting or has acted in breach of its obligations under this Convention may inform the Secretariat thereof, and in such an event, shall simultaneously and immediately inform, directly or through the Secretariat, the Party against whom the allegations are made. All relevant information should be submitted by the Secretariat to the Parties.

Article 20

Settlement of Disputes

1. In case of a dispute between Parties as to the interpretation or application of, or compliance with, this Convention or any protocol thereto, they shall seek a settlement of the dispute through negotiation or any other peaceful means of their own choice.

2. If the Parties concerned cannot settle their dispute through the means mentioned in the preceding paragraph, the dispute, if the Parties to the dispute agree, shall be submitted to the International Court of Justice or to arbitration under the conditions set out in Annex VI on Arbitration. However, failure to reach common agreement on submission of the dispute to the International Court of Justice or to arbitration shall not absolve the Parties from the responsibility of continuing to seek to resolve it by the means referred to in paragraph 1.

3. When ratifying, accepting, approving, formally confirming or acceding to this Convention, or at any time thereafter, a State or political and/or economic integration organization may declare that it recognizes as compulsory ipso facto and without special agreement, in relation to any Party accepting the same obligation:

(a) submission of the dispute to the International Court of Justice; and/or

(b) arbitration in accordance with the procedures set out in Annex VI.

Such declaration shall be notified in writing to the Secretariat which shall communicate it to the Parties.

Article 21

Signature

This Convention shall be open for signature by States, by Namibia, represented by the United Nations Council for Namibia, and by political and/or economic integration organizations, in Basel on 22 March 1989, at the Federal Department of Foreign Affairs of Switzerland in Berne from 23 March 1989 to 30 June 1989 and at United Nations Headquarters in New York from 1 July 1989 to 22 March 1990.

Article 22

Ratification, Acceptance, Formal Confirmation or Approval

1. This Convention shall be subject to ratification, acceptance or approval by States and by Namibia, represented by the United Nations Council for Namibia, and to formal confirmation or approval by political and/or economic integration organizations. Instruments of ratification, acceptance, formal confirmation, or approval shall be deposited with the Depositary.

2. Any organization referred to in paragraph 1 above which becomes a Party to this Convention without any of its member States being a Party shall be bound by all the obligations under the Convention. In the case of such organizations, one or more of whose member States is a Party to the Convention, the organization and its member States shall decide on their respective responsibilities for the performance of their obligations under the Convention. In such cases, the organization and the member States shall not be entitled to exercise rights under the Convention concurrently.

3. In their instruments of formal confirmation or approval, the organizations referred to in paragraph 1 above shall declare the extent of their competence with respect to the matters governed by the Convention. These organizations shall also inform the Depositary, who will inform the Parties of any substantial modification in the extent of their competence.

Article 23

Accession

1. This Convention shall be open for accession by States, by Namibia, represented by the United Nations Council for Namibia, and by political and/or economic integration organizations from the day after the date on which the Convention is closed for signature. The instruments of accession shall be deposited with the Depositary.

2. In their instruments of accession, the organizations referred to in paragraph 1 above shall declare the extent of their competence with respect to the matters governed by the Convention. These organizations shall also inform the Depositary of any substantial modification in the extent

of their competence.

3. The provisions of Article 22, paragraph 2, shall apply to political and/or economic integration organizations which accede to this Convention.

Article 24

Right to Vote

1. Except as provided for in paragraph 2 below, each Contracting Party to this Convention shall have one vote.

2. Political and/or economic integration organizations, in matters within their competence, in accordance with Article 22, paragraph 3, and Article 23, paragraph 2, shall exercise their right to vote with a number of votes equal to the number of their member States which are Parties to the Convention or the relevant protocol. Such organizations shall not exercise their right to vote if their member States exercise theirs, and vice versa.

Article 25

Entry into Force

1. This Convention shall enter into force on the ninetieth day after the date of deposit of the twentieth instrument of ratification, acceptance, formal confirmation, approval or accession.

2. For each State or political and/or economic integration organization which ratifies, accepts, approves or formally confirms this Convention or accedes thereto after the date of the deposit of the twentieth instrument of ratification, acceptance, approval, formal confirmation or accession, it shall enter into force on the ninetieth day after the date of deposit by such State or political and/or economic integration organization of its instrument of ratification, acceptance, approval, formal confirmation or accession.

3. For the purpose of paragraphs 1 and 2 above, any instrument deposited by a political and/or economic integration organization shall not be counted as additional to those deposited by member States of such organization.

Article 26

Reservations and Declarations

1. No reservation or exception may be made to this Convention.

2. Paragraph 1 of this Article does not preclude a State or political and/or economic integration organization, when signing, ratifying, accepting, approving, formally confirming or acceding to this Convention, from making declarations or statements, however phrased or named, with a view, inter alia, to the harmonization of its laws and regulations with the provisions of this Convention, provided that such declarations or statements do not purport to exclude or to modify the legal effects of the provisions of the Convention in their application to that State.

Article 27

Withdrawal

1. At any time after three years from the date on which this Convention has entered into force for a Party, that Party may withdraw from the Convention by giving written notification to the Depositary.

2. Withdrawal shall be effective one year from receipt of notification by the Depositary, or on such later date as may be specified in the notification.

Article 28

Depository

The Secretary-General of the United Nations shall be the Depository of this Convention and of any protocol thereto.

Article 29

Authentic texts

The original Arabic, Chinese, English, French, Russian and Spanish texts of this Convention are equally authentic.

IN WITNESS WHEREOF the undersigned, being duly authorized to that effect, have signed this Convention.

Done at.....Basel.....on the.....22.....day of.....March.....1989

Annex I

CATEGORIES OF WASTES TO BE CONTROLLED

Waste	Streams

Y1

Clinical wastes from medical care in hospitals, medical centers and clinics

Y2

Wastes from the production and preparation of pharmaceutical products

Y3

Waste pharmaceuticals, drugs and medicines

Y4

Wastes from the production, formulation and use of biocides and phytopharmaceuticals

Y5

Wastes from the manufacture, formulation and use of wood preserving chemicals

Y6

Wastes from the production, formulation and use of organic solvents

Y7

Wastes from heat treatment and tempering operations containing cyanides

Y8

Waste mineral oils unfit for their originally intended use

Y9

Waste oils/water, hydrocarbons/water mixtures, emulsions

Y10

Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)

Y11

Waste tarry residues arising from refining, distillation and any pyrolytic treatment

Y12

Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish

Y13

Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives

Y14

Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known

Y15

Wastes of an explosive nature not subject to other legislation

Y16

Wastes from production, formulation and use of photographic chemicals and processing materials

Y17

Wastes resulting from surface treatment of metals and plastics

Y18

Residues arising from industrial waste disposal operations

Wastes having as constituents:

Y19

Metal carbonyls

Y20

Beryllium; beryllium compounds

Y21

Hexavalent chromium compounds

Y22

Copper compounds

Y23

Zinc compounds

Y24

Arsenic; arsenic compounds

Y25

Selenium; selenium compounds

Y26

Cadmium; cadmium compounds

Y27

Antimony; antimony compounds

Y28

Tellurium; tellurium compounds

Y29

Mercury; mercury compounds

Y30

Thallium; thallium compounds

Y31

Lead; lead compounds

Y32

Inorganic fluorine compounds excluding calcium fluoride

Y33

Inorganic cyanides

Y34

Acidic solutions or acids in solid form

Y35

Basic solutions or bases in solid form

Y36

Asbestos (dust and fibres)

Y37

Organic phosphorus compounds

Y38

Organic cyanides

Y39

Phenols; phenol compounds including chlorophenols

Y40

Ethers

Y41

Halogenated organic solvents

Y42

Organic solvents excluding halogenated solvents

Y43

Any congenor of polychlorinated dibenzo-furan

Y44

Any congenor of polychlorinated dibenzo-p-dioxin

Y45

Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44)

(a) To facilitate the application of this Convention, and subject to paragraphs (b), (c) and (d), wastes listed in Annex VIII are characterized as hazardous pursuant to Article 1, paragraph 1 (a), of this Convention, and wastes listed in Annex IX are not covered by Article 1, paragraph 1 (a), of this Convention.

(b) Designation of a waste on Annex VIII does not preclude, in a particular case, the use of Annex III to demonstrate that a waste is not hazardous pursuant to Article 1, paragraph 1 (a), of this Convention.

(c) Designation of a waste on Annex IX does not preclude, in a particular case, characterization of such a waste as hazardous pursuant to Article 1, paragraph 1 (a), of this Convention if it contains Annex I material to an extent causing it to exhibit an Annex III characteristic.

(d) Annexes VIII and IX do not affect the application of Article 1, paragraph 1 (a), of this Convention for the purpose of characterization of wastes[3]

Annex II

CATEGORIES OF WASTES REQUIRING SPECIAL CONSIDERATION

Y46
Wastes collected from households

Y47
Residues arising from the incineration of household wastes

[3]Decision IV/9 adopted by the Conference of Parties at its fourth meeting modified Annex I by adding paragraphs (a), (b), (c) and (d) at the end of Annex I. The amendments under Decision IV/9 entered into force on 6 November 1998.

Annex III

LIST OF HAZARDOUS CHARACTERISTICS

UN Class[4]	Code	Characteristics
1	H1	Explosive An explosive substance or waste is a solid or liquid substance or waste (or mixture of substances or wastes) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.
3	H3	Flammable liquids The word "flammable" has the same meaning as "inflammable". Flammable liquids are liquids, or mixtures of liquids, or liquids containing solids in solution or suspension (for example, paints, varnishes, lacquers, etc., but not including substances or wastes otherwise classified on account of their dangerous characteristics) which give off a flammable vapour at temperatures of not more than 60.5ºC, closed-cup test, or not more than 65.6ºC, open-cup test. (Since the results of open-cup tests and of closed-cup tests are not strictly comparable and even individual results by the same test are often variable, regulations varying from the above figures to make allowance for such differences would be within the spirit of this definition.)
4.1	H4.1	Flammable solids

Solids, or waste solids, other than those classed as explosives, which under conditions encountered in transport are readily combustible, or may cause or contribute to fire through friction.

4.2

H4.2

Substances or wastes liable to spontaneous combustion
Substances or wastes which are liable to spontaneous heating under normal conditions encountered in transport, or to heating up on contact with air, and being then liable to catch fire.

4.3

H4.3

Substances or wastes which, in contact with water emit flammable gases
Substances or wastes which, by interaction with water, are liable to become spontaneously flammable or to give off flammable gases in dangerous quantities.

5.1

H5.1

Oxidizing
Substances or wastes which, while in themselves not necessarily combustible, may, generally by yielding oxygen cause, or contribute to, the combustion of other materials.

5.2

H5.2

Organic Peroxides
Organic substances or wastes which contain the bivalent-o-o-structure are thermally unstable substances which may undergo exothermic self-accelerating decomposition.

6.1

H6.1

Poisonous (Acute)
Substances or wastes liable either to cause death or serious injury or to harm health if swallowed or inhaled or by skin contact.

6.2

H6.2

Infectious substances
Substances or wastes containing viable micro organisms or their toxins which are known or suspected to cause disease in animals or humans.

8

H8

Corrosives
Substances or wastes which, by chemical action, will cause severe damage when in contact with living tissue, or, in the case of leakage, will materially damage, or even destroy, other goods or the means of transport; they may also cause other hazards.

9

H10

Liberation of toxic gases in contact with air or water
Substances or wastes which, by interaction with air or water, are liable to give off toxic gases in dangerous quantities.

9

H11
Toxic (Delayed or chronic)
Substances or wastes which, if they are inhaled or ingested or if they penetrate the skin, may involve delayed or chronic effects, including carcinogenicity.

9

H12

Ecotoxic
Substances or wastes which if released present or may present immediate or delayed adverse impacts to the environment by means of bioaccumulation and/or toxic effects upon biotic systems.

9

H13

Capable, by any means, after disposal, of yielding another material, e.g., leachate, which possesses any of the characteristics listed above.

[4]Corresponds to the hazard classification system included in the United Nations Recommendations on the Transport of Dangerous Goods (ST/SG/AC.10/1Rev.5, United Nations, New York, 1988).

Tests

The potential hazards posed by certain types of wastes are not yet fully documented; tests to define quantitatively these hazards do not exist. Further research is necessary in order to develop means to characterize potential hazards posed to man and/or the environment by these wastes. Standardized tests have been derived with respect to pure substances and materials. Many countries have developed national tests which can be applied to materials listed in Annex I, in order to decide if these materials exhibit any of the characteristics listed in this Annex.

Annex IV

DISPOSAL OPERATIONS

A. OPERATIONS WHICH DO NOT LEAD TO THE POSSIBILITY OF RESOURCE RECOVERY, RECYCLING, RECLAMATION, DIRECT RE-USE OR ALTERNATIVE USES

Section A encompasses all such disposal operations which occur in practice.

D1

Deposit into or onto land, (e.g., landfill, etc.)

D2

Land treatment, (e.g., biodegradation of liquid or sludgy discards in soils, etc.)

D3

Deep injection, (e.g., injection of pumpable discards into wells, salt domes of naturally occurring repositories, etc.)

D4

Surface impoundment, (e.g., placement of liquid or sludge discards into pits, ponds or lagoons, etc.)

D5

Specially engineered landfill, (e.g., placement into lined discrete cells which are capped and isolated from one another and the environment, etc.)

D6

Release into a water body except seas/oceans

D7

Release into seas/oceans including sea-bed insertion

D8

Biological treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations in Section A

D9

Physico chemical treatment not specified elsewhere in this Annex which results in final compounds or mixtures which are discarded by means of any of the operations in Section A, (e.g., evaporation, drying, calcination, neutralization, precipitation, etc.)

D10

Incineration on land

D11

Incineration at sea

D12

Permanent storage (e.g., emplacement of containers in a mine, etc.)

D13

Blending or mixing prior to submission to any of the operations in Section A

D14

Repackaging prior to submission to any of the operations in Section A

D15

Storage pending any of the operations in Section A

B. OPERATIONS WHICH MAY LEAD TO RESOURCE RECOVERY, RECYCLING RECLAMATION, DIRECT RE-USE OR ALTERNATIVE USES

Section B encompasses all such operations with respect to materials legally defined as or

considered to be hazardous wastes and which otherwise would have been destined for operations included in Section A

R1

Use as a fuel (other than in direct incineration) or other means to generate energy

R2

Solvent reclamation/regeneration

R3

Recycling/reclamation of organic substances which are not used as solvents

R4

Recycling/reclamation of metals and metal compounds

R5

Recycling/reclamation of other inorganic materials

R6

Regeneration of acids or bases

R7

Recovery of components used for pollution abatement

R8

Recovery of components from catalysts

R9

Used oil re-refining or other reuses of previously used oil

R10

Land treatment resulting in benefit to agriculture or ecological improvement

R11

Uses of residual materials obtained from any of the operations numbered R1-R10

R12

Exchange of wastes for submission to any of the operations numbered R1-R11

R13

Accumulation of material intended for any operation in Section B

Annex V A

INFORMATION TO BE PROVIDED ON NOTIFICATION

1. Reason for waste export
2. Exporter of the waste 1/
3. Generator(s) of the waste and site of generation 1/
4. Disposer of the waste and actual site of disposal 1/
5. Intended carrier(s) of the waste or their agents, if known 1/
6. Country of export of the waste Competent authority 2/
7. Expected countries of transit Competent authority 2/
8. Country of import of the waste General or single notification
9. Projected date(s) of shipment(s) and period of time over which waste is to be exported and proposed itinerary (including point of entry and exit) 3/
10. Means of transport envisaged (road, rail, sea, air, inland waters)
11. Information relating to insurance 4/
12. Designation and physical description of the waste including Y number and UN number and its composition 5/ and information on any special handling requirements including emergency provisions in case of accidents
13. Type of packaging envisaged (e.g. bulk, drummed, tanker)
14. Estimated quantity in weight/volume 6/
15. Process by which the waste is generated 7/

16. For wastes listed in Annex I, classifications from Annex III: hazardous characteristic, H number, and UN class

17. Method of disposal as per Annex IV

18. Declaration by the generator and exporter that the information is correct

19. Information transmitted (including technical description of the plant) to the exporter or generator from the disposer of the waste upon which the latter has based his assessment that there was no reason to believe that the wastes will not be managed in an environmentally sound manner in accordance with the laws and regulations of the country of import

20. Information concerning the contract between the exporter and disposer.

Notes

1/ Full name and address, telephone or telefax number and the name, address, telephone, telex or telefax number of the person to be contacted.

2/ Full name and address, telephone, telex or telefax number.

3/ In the case of a general notification covering several shipments, either the expected dates of each shipment or, if this is not known, the expected frequency of the shipments will be required.

4/ Information to be provided on relevant insurance requirements and how they are met by exporter, carrier and disposer.

5/ The nature and the concentration of the most hazardous components, in terms of toxicity and other dangers presented by the waste both in handling and in relation to the proposed disposal method.

6/ In the case of a general notification covering several shipments, both the estimated total quantity and the estimated quantities for each individual shipment will be required.

7/ Insofar as this is necessary to assess the hazard and determine the appropriateness of the proposed disposal operation.

Annex V B

INFORMATION TO BE PROVIDED ON THE MOVEMENT DOCUMENT

1. Exporter of the waste 1/

2. Generator(s) of the waste and site of generation 1/

3. Disposer of the waste and actual site of disposal 1/

4. Carrier(s) of the waste 1/ or his agent(s)

5. Subject of general or single notification

6. The date the transboundary movement started and date(s) and signature on receipt by each person who takes charge of the waste

7. Means of transport (road, rail, inland waterway, sea, air) including countries of export, transit and import, also point of entry and exit where these have been designated

8. General description of the waste (physical state, proper UN shipping name and class, UN number, Y number and H number as applicable)

9. Information on special handling requirements including emergency provision in case of accidents

10. Type and number of packages

11. Quantity in weight/volume

12. Declaration by the generator or exporter that the information is correct

13. Declaration by the generator or exporter indicating no objection from the competent authorities of all States concerned which are Parties

14. Certification by disposer of receipt at designated disposal facility and indication of method of disposal and of the approximate date of disposal.

Notes

The information required on the movement document shall where possible be integrated in one document with that required under transport rules. Where this is not possible the information should complement rather than duplicate that required under the transport rules. The movement document shall carry instructions as to who is to provide information and fill-out any form.

1/ Full name and address, telephone or telefax number and the name, address, telephone, telex or telefax number of the person to be contacted in case of emergency.

Annex VI

ARBITRATION

Article 1

Unless the agreement referred to in Article 20 of the Convention provides otherwise, the arbitration procedure shall be conducted in accordance with Articles 2 to 10 below.

Article 2

The claimant Party shall notify the Secretariat that the Parties have agreed to submit the dispute to arbitration pursuant to paragraph 2 or paragraph 3 of Article 20 and include, in particular, the Articles of the Convention the interpretation or application of which are at issue. The Secretariat shall forward the information thus received to all Parties to the Convention.

Article 3

The arbitral tribunal shall consist of three members. Each of the Parties to the dispute shall appoint an arbitrator, and the two arbitrators so appointed shall designate by common agreement the third arbitrator, who shall be the chairman of the tribunal. The latter shall not be a national of one of the Parties to the dispute, nor have his usual place of residence in the territory of one of these Parties, nor be employed by any of them, nor have dealt with the case in any other capacity.

Article 4

1. If the chairman of the arbitral tribunal has not been designated within two months of the appointment of the second arbitrator, the Secretary-General of the United Nations shall, at the request of either Party, designate him within a further two months period.

2. If one of the Parties to the dispute does not appoint an arbitrator within two months of the receipt of the request, the other Party may inform the Secretary-General of the United Nations who shall designate the chairman of the arbitral tribunal within a further two months' period. Upon designation, the chairman of the arbitral tribunal shall request the Party which has not appointed an arbitrator to do so within two months. After such period, he shall inform the Secretary-General of the United Nations, who shall make this appointment within a further two months' period.

Article 5

1. The arbitral tribunal shall render its decision in accordance with international law and in accordance with the provisions of this Convention.

2. Any arbitral tribunal constituted under the provisions of this Annex shall draw up its own rules of procedure.

Article 6

1. The decisions of the arbitral tribunal both on procedure and on substance, shall be taken by majority vote of its members.

2. The tribunal may take all appropriate measures in order to establish the facts. It may, at the request of one of the Parties, recommend essential interim measures of protection.

3. The Parties to the dispute shall provide all facilities necessary for the effective conduct of the proceedings.

4. The absence or default of a Party in the dispute shall not constitute an impediment to the proceedings.

Article 7

The tribunal may hear and determine counter-claims arising directly out of the subject-matter of the dispute.

Article 8

Unless the arbitral tribunal determines otherwise because of the particular circumstances of the case, the expenses of the tribunal, including the remuneration of its members, shall be borne by the Parties to the dispute in equal shares. The tribunal shall keep a record of all its expenses, and shall furnish a final statement thereof to the Parties.

Article 9

Any Party that has an interest of a legal nature in the subject-matter of the dispute which may be affected by the decision in the case, may intervene in the proceedings with the consent of the tribunal.

Article 10

1. The tribunal shall render its award within five months of the date on which it is established unless it finds it necessary to extend the time-limit for a period which should not exceed five months.

2. The award of the arbitral tribunal shall be accompanied by a statement of reasons. It shall be final and binding upon the Parties to the dispute.

3. Any dispute which may arise between the Parties concerning the interpretation or execution of the award may be submitted by either Party to the arbitral tribunal which made the award or, if the latter cannot be seized thereof, to another tribunal constituted for this purpose in the same manner as the first.

Annex VII

[not yet entered into force][5]

[5]Annex VII is an integral part of the Amendment adopted by the third meeting of the Conference of the Parties in 1995 in its Decision III/1. The amendment is not yet in force. Decision III/1 provides as follows:

"Decision III/1
Amendment to the Basel Convention

The Conference,

…

3. Decides to adopt the following amendment to the Convention:

'Insert new preambular paragraph 7 bis:

Recognizing that transboundary movements of hazardous wastes, especially to developing countries, have a high risk of not constituting an environmentally sound management of hazardous wastes as required by this Convention;

Insert new Article 4A:

1. Each Party listed in Annex VII shall prohibit all transboundary movements of hazardous wastes which are destined for operations according to Annex IV A, to States not listed in Annex VII.

2. Each Party listed in Annex VII shall phase out by 31 December 1997, and prohibit as of that date, all transboundary movements of hazardous wastes under Article 1(1)(a) of the Convention which are destined for operations according to Annex IV B to States not listed in Annex VII. Such transboundary movement shall not be prohibited unless the wastes in question are characterised as hazardous under the Convention.

Annex VII

Parties and other States which are members of OECD, EC, Liechtenstein'"

Annex VIII[6]

LIST A

Wastes contained in this Annex are characterized as hazardous under Article 1, paragraph 1 (a), of this Convention, and their designation on this Annex does not preclude the use of Annex III to demonstrate that a waste is not hazardous.

A1 Metal and metal-bearing wastes

A1010

Metal wastes and waste consisting of alloys of any of the following:

- Antimony
- Arsenic
- Beryllium
- Cadmium
- Lead
- Mercury
- Selenium
- Tellurium
- Thallium

but excluding such wastes specifically listed on list B.

A1020

Waste having as constituents or contaminants, excluding metal waste in massive form, any of the following:

- Antimony; antimony compounds
- Beryllium; beryllium compounds
- Cadmium; cadmium compounds
- Lead; lead compounds
- Selenium; selenium compounds
- Tellurium; tellurium compounds

A1030

Wastes having as constituents or contaminants any of the following:

- Arsenic; arsenic compounds
- Mercury; mercury compounds
- Thallium; thallium compounds

A1040

Wastes having as constituents any of the following:

Metal carbonyls

Hexavalent chromium compounds

[6]Decision IV/9 adopted by the Conference of Parties at its fourth meeting modified the Convention by adding a new Annex VIII. The amendments under Decision IV/9 entered into force on 6 November 1998. Decision VI/35 adopted by the Conference of the Parties at its Sixth Meeting further amended Annex VIII by adding new entries. The amendments under Decision VI/35 entered into force on 20 November 2003. The present text includes all amendments

A1050

Galvanic sludges

A1060

Waste liquors from the pickling of metals

A1070

Leaching residues from zinc processing, dust and sludges such as jarosite, hematite, etc.

A1080

Waste zinc residues not included on list B, containing lead and cadmium in concentrations sufficient to exhibit Annex III characteristics

A1090

Ashes from the incineration of insulated copper wire

A1100

Dusts and residues from gas cleaning systems of copper smelters

A1110

Spent electrolytic solutions from copper electrorefining and electrowinning operations

A1120

Waste sludges, excluding anode slimes, from electrolyte purification systems in copper electrorefining and electrowinning operations

A1130

Spent etching solutions containing dissolved copper

A1140

Waste cupric chloride and copper cyanide catalysts

A1150

Precious metal ash from incineration of printed circuit boards not included on list B[7]

A1160

Waste lead-acid batteries, whole or crushed

A1170

Unsorted waste batteries excluding mixtures of only list B batteries. Waste batteries not specified on list B containing Annex I constituents to an extent to render them hazardous

A1180

Waste electrical and electronic assemblies or scrap[8] containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or contaminated with Annex I constituents (e.g., cadmium, mercury, lead, polychlorinated biphenyl) to an extent that they possess any of the characteristics contained in Annex III (note the related entry on list B B1110)[9]

[7] Note that mirror entry on list B (B1160) does not specify exceptions.

[8] This entry does not include scrap assemblies from electric power generation.

[9] PCBs are at a concentration level of 50 mg/kg or

A2 Wastes containing principally inorganic constituents, which may contain metals and organic materials

A2010

Glass waste from cathode-ray tubes and other activated glasses

A2020

Waste inorganic fluorine compounds in the form of liquids or sludges but excluding such wastes specified on list B

A2030

Waste catalysts but excluding such wastes specified on list B

A2040

Waste gypsum arising from chemical industry processes, when containing Annex I constituents to the extent that it exhibits an Annex III hazardous characteristic (note the related entry on list B B2080)

A2050

Waste asbestos (dusts and fibres)

A2060

Coal-fired power plant fly-ash containing Annex I substances in concentrations sufficient to exhibit Annex III characteristics (note the related entry on list B B2050)

A3 Wastes containing principally organic constituents, which may contain metals and inorganic materials

A3010

Waste from the production or processing of petroleum coke and bitumen

A3020

Waste mineral oils unfit for their originally intended use

A3030

Wastes that contain, consist of or are contaminated with leaded anti-knock compound sludges

A3040

Waste thermal (heat transfer) fluids

A3050

Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives excluding such wastes specified on list B (note the related entry on list B B4020)

A3060

Waste nitrocellulose

A3070

Waste phenols, phenol compounds including chlorophenol in the form of liquids or sludges

A3080

Waste ethers not including those specified on list B

A3090

Waste leather dust, ash, sludges and flours when containing hexavalent chromium compounds or biocides (note the related entry on list B B3100)

A3100

Waste paring and other waste of leather or of composition leather not suitable for the manufacture of leather articles containing hexavalent chromium compounds or biocides (note the related entry on list B B3090)

A3110

Fellmongery wastes containing hexavalent chromium compounds or biocides or infectious substances (note the related entry on list B B3110)

A3120

Fluff - light fraction from shredding

A3130

Waste organic phosphorous compounds

A3140

Waste non-halogenated organic solvents but excluding such wastes specified on list B

A3150

Waste halogenated organic solvents

A3160

Waste halogenated or unhalogenated non-aqueous distillation residues arising from organic solvent recovery operations

A3170

Wastes arising from the production of aliphatic halogenated hydrocarbons (such as chloromethane, dichloro-ethane, vinyl chloride, vinylidene chloride, allyl chloride and epichlorhydrin)

A3180

Wastes, substances and articles containing, consisting of or contaminated with polychlorinated biphenyl (PCB), polychlorinated terphenyl (PCT), polychlorinated naphthalene (PCN) or polybrominated biphenyl (PBB), or any other polybrominated analogues of these compounds, at a concentration level of 50 mg/kg or more[10]

A3190

Waste tarry residues (excluding asphalt cements) arising from refining, distillation and any pyrolitic treatment of organic materials

A3200

Bituminous material (asphalt waste) from road construction and maintenance, containing tar (note the related entry on list B, B2130)

A4 Wastes which may contain either inorganic or organic constituents

A4010

Wastes from the production, preparation and use of pharmaceutical products but excluding such wastes specified on list B

A4020

Clinical and related wastes; that is wastes arising from medical, nursing, dental, veterinary, or similar practices, and wastes generated in hospitals or other facilities during the investigation or treatment of patients, or research projects

[10] The 50 mg/kg level is considered to be an internationally practical level for all wastes. However, many individual countries have established lower regulatory levels (e.g., 20 mg/kg) for specific wastes

A4030

Wastes from the production, formulation and use of biocides and phytopharmaceuticals, including waste pesticides and herbicides which are off-specification, outdated [11], or unfit for their originally intended use

A4040

Wastes from the manufacture, formulation and use of wood-preserving chemicals [12]

A4050

Wastes that contain, consist of or are contaminated with any of the following:

Inorganic cyanides, excepting precious-metal-bearing residues in solid form containing traces of inorganic cyanides Organic cyanides

A4060

Waste oils/water, hydrocarbons/water mixtures, emulsions

A4070

Wastes from the production, formulation and use of inks, dyes, pigments, paints, lacquers, varnish excluding any such waste specified on list B (note the related entry on list B B4010)

A4080

Wastes of an explosive nature (but excluding such wastes specified on list B)

A4090

Waste acidic or basic solutions, other than those specified in the corresponding entry on list B (note the related entry on list B B2120)

A4100

Wastes from industrial pollution control devices for cleaning of industrial off-gases but excluding such wastes specified on list B

A4110
Wastes that contain, consist of or are contaminated with any of the following:
- Any congenor of polychlorinated dibenzo-furan
- Any congenor of polychlorinated dibenzo-dioxin

A4120

Wastes that contain, consist of or are contaminated with peroxides

A4130

Waste packages and containers containing Annex I substances in concentrations sufficient to exhibit Annex III hazard characteristics

A4140

Waste consisting of or containing off specification or outdated [13] chemicals corresponding to Annex I categories and exhibiting Annex III hazard characteristics

[11] Note that mirror entry on list B (B1160) does not specify exceptions.
[12] This entry does not include scrap assemblies from electric power generation.
[13] PCBs are at a concentration level of 50 mg/kg or more.

A4150

Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on human health and/or the environment are not known

A4160

Spent activated carbon not included on list B (note the related entry on list B B2060)

Annex IX [14]

LIST B

Wastes contained in the Annex will not be wastes covered by Article 1, paragraph 1 (a), of this Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic.

B1 Metal and metal-bearing wastes

B1010

Metal and metal-alloy wastes in metallic, non-dispersible form:

- Precious metals (gold, silver, the platinum group, but not mercury)
- Iron and steel scrap
- Copper scrap
- Nickel scrap
- Aluminium scrap
- Zinc scrap
- Tin scrap
- Tungsten scrap
- Molybdenum scrap

- Tantalum scrap
- Magnesium scrap
- Cobalt scrap
- Bismuth scrap
- Titanium scrap
- Zirconium scrap
- Manganese scrap
- Germanium scrap
- Vanadium scrap
- Scrap of hafnium, indium, niobium, rhenium and gallium
- Thorium scrap
- Rare earths scrap

- Chromium scrap

[14] Decision IV/9 adopted by the Conference of Parties at its fourth meeting modified the Convention by adding a new Annex IX. The amendments under Decision IV/9 entered into force on 6 November 1998. Decision VI/35 adopted by the Conference of the Parties at its Sixth Meeting further amended Annex IX by adding new entries. The amendments under Decision VI/35 entered into force on 20 November 2003. The present text includes all amendments.

B1020

Clean, uncontaminated metal scrap, including alloys, in bulk finished form (sheet, plate, beams, rods, etc), of:

- Antimony scrap

- Beryllium scrap

- Cadmium scrap

- Lead scrap (but excluding lead-acid batteries)

- Selenium scrap

- Tellurium scrap

B1030

Refractory metals containing residues

B1031

Molybdenum, tungsten, titanium, tantalum, niobium and rhenium metal and metal alloy wastes in metallic dispersible form (metal powder), excluding such wastes as specified in list A under entry A1050, Galvanic sludges

B1040

Scrap assemblies from electrical power generation not contaminated with lubricating oil, PCB or PCT to an extent to render them hazardous

B1050

Mixed non-ferrous metal, heavy fraction scrap, not containing Annex I materials in concentrations sufficient to exhibit Annex III characteristics [15]

B1060

Waste selenium and tellurium in metallic elemental form including powder

B1070

Waste of copper and copper alloys in dispersible form, unless they contain Annex I constituents to an extent that they exhibit Annex III characteristics

B1080

Zinc ash and residues including zinc alloys residues in dispersible form unless containing Annex I constituents in concentration such as to exhibit Annex III characteristics or exhibiting hazard characteristic H4.3 [16]

B1090

Waste batteries conforming to a specification, excluding those made with lead, cadmium or mercury

B1100

Metal-bearing wastes arising from melting, smelting and refining of metals:

- Hard zinc spelter

- Zinc-containing drosses:

  - Galvanizing slab zinc top dross (>90% Zn)

- Galvanizing slab zinc bottom dross (>92% Zn)
- Zinc die casting dross (>85% Zn)
- Hot dip galvanizers slab zinc dross (batch)(>92% Zn)
- Zinc skimmings

- Aluminium skimmings (or skims) excluding salt slag
- Slags from copper processing for further processing or refining not containing arsenic, lead or cadmium to an extent that they exhibit Annex III hazard characteristics
- Wastes of refractory linings, including crucibles, originating from copper smelting
- Slags from precious metals processing for further refining
- Tantalum-bearing tin slags with less than 0.5% tin

15 Note that even where low level contamination with Annex I materials initially exists, subsequent processes, including recycling processes, may result in separated fractions containing significantly enhanced concentrations of those Annex I materials.

16 The status of zinc ash is currently under review and there is a recommendation with the United Nations Conference on Trade and Development (UNCTAD) that zinc ashes should not be dangerous goods.

B1110

- Electrical and electronic assemblies:

- Electronic assemblies consisting only of metals or alloys

- Waste electrical and electronic assemblies or scrap [17] (including printed circuit boards) not containing components such as accumulators and other batteries included on list A, mercury-switches, glass from cathode-ray tubes and other activated glass and PCB-capacitors, or not contaminated with Annex I constituents (e.g., cadmium, mercury, lead, polychlorinated biphenyl) or from which these have been removed, to an extent that they do not possess any of the characteristics contained in Annex III (note the related entry on list A A1180)

- Electrical and electronic assemblies (including printed circuit boards, electronic components and wires) destined for direct reuse [18], and not for recycling [19] or final disposal

B1120

Spent catalysts excluding liquids used as catalysts, containing any of:

Transition metals, excluding waste catalysts (spent catalysts, liquid used catalysts or other catalysts) on list A

Scandium
Vanadium
Manganese
Cobalt
Copper
Yttrium
Niobium
Hafnium
Tungsten

Titanium
Chromium

Iron
Nickel
Zinc
Zirconium
Molybdenum
Tantalum
Rhenium

Lanthanides (rare earth metals):

Lanthanum
Praseodymium
Samarium
Gadolinium
Dysprosium
Erbium
Ytterbium

Cerium
Neody
Europium
Terbium
Holmium
Thulium
Lutetium

[17] This entry does not include scrap from electrical power generation.

18 Reuse can include repair, refurbishment or upgrading, but not major reassembly. 19 In some countries these materials destined for direct re-use are not considered wastes.

B1130

Cleaned spent precious-metal-bearing catalysts

B1140

Precious-metal-bearing residues in solid form which contain traces of inorganic cyanides

B1150

Precious metals and alloy wastes (gold, silver, the platinum group, but not mercury) in a dispersible, non-liquid form with appropriate packaging and labelling

B1160

Precious-metal ash from the incineration of printed circuit boards (note the related entry on list A A1150)

B1170

Precious-metal ash from the incineration of photographic film

B1180

Waste photographic film containing silver halides and metallic silver

B1190

Waste photographic paper containing silver halides and metallic silver

B1200

Granulated slag arising from the manufacture of iron and steel

B1210

Slag arising from the manufacture of iron and steel including slags as a source of TiO_2 and vanadium

B1220

Slag from zinc production, chemically stabilized, having a high iron content (above 20%) and processed according to industrial specifications (e.g., DIN 4301) mainly for construction

B1230

Mill scaling arising from the manufacture of iron and steel

B1240

Copper oxide mill-scale

B1250

Waste end-of-life motor vehicles, containing neither liquids nor hazardous components

B2 Wastes containing principally inorganic constituents, which may contain metals and organic materials

B2010

Wastes from mining operations in non-dispersible form:

- Natural graphite waste
- Slate waste, whether or not roughly trimmed or merely cut, by sawing or otherwise
- Mica waste
- Leucite, nepheline and nepheline syenite waste
- Feldspar waste

- Fluorspar waste

- Silica wastes in solid form excluding those used in foundry operations

B2020

Glass waste in non-dispersible form:

- Cullet and other waste and scrap of glass except for glass from cathode-ray tubes and other activated glasses

B2030

Ceramic wastes in non-dispersible form:

- Cermet wastes and scrap (metal ceramic composites)

- Ceramic based fibres not elsewhere specified or included

B2040

Other wastes containing principally inorganic constituents:

- Partially refined calcium sulphate produced from flue-gas desulphurization (FGD)

- Waste gypsum wallboard or plasterboard arising from the demolition of buildings

- Slag from copper production, chemically stabilized, having a high iron content (above 20%) and processed according to industrial specifications (e.g., DIN 4301 and DIN 8201) mainly for construction and abrasive applications

- Sulphur in solid form

- Limestone from the production of calcium cyanamide (having a pH less than 9)

- Sodium, potassium, calcium chlorides

- Carborundum (silicon carbide)

- Broken concrete

- Lithium-tantalum and lithium-niobium containing glass scraps

B2050

Coal-fired power plant fly-ash, not included on list A (note the related entry on list A A2060)

B2060

Spent activated carbon not containing any Annex I constituents to an extent they exhibit Annex III characteristics, for example, carbon resulting from the treatment of potable water and processes of the food industry and vitamin production (note the related entry on list A, A4160);

B2070

Calcium fluoride sludge

B2080

Waste gypsum arising from chemical industry processes not included on list A (note the related entry on list A A2040)

B2090

Waste anode butts from steel or aluminium production made of petroleum coke or bitumen and cleaned to normal industry specifications (excluding anode butts from chlor alkali electrolyses and from metallurgical industry)

B2100

Waste hydrates of aluminium and waste alumina and residues from alumina production excluding such materials used for gas cleaning, flocculation or filtration processes

B2110

Bauxite residue ("red mud") (pH moderated to less than 11.5)

B2120

Waste acidic or basic solutions with a pH greater than 2 and less than 11.5, which are not corrosive or otherwise hazardous (note the related entry on list A A4090)

B2130

Bituminous material (asphalt waste) from road construction and maintenance, not containing tara (note the related entry on list A, A3200)

B3 Wastes containing principally organic constituents, which may contain metals and inorganic materials

B3010

Solid plastic waste:

The following plastic or mixed plastic materials, provided they are not mixed with other wastes and are

prepared to a specification:

- Scrap plastic of non-halogenated polymers and co-polymers, including but not limited to the following [18]

  - ethylene
  - styrene
  - polypropylene
  - polyethylene terephthalate
  - acrylonitrile
  - butadiene
  - polyacetals
  - polyamides
  - polybutylene terephthalate
  - polycarbonates

- polyethers
- polyphenylene sulphides
- acrylic polymers
- alkanes C10-C13 (plasticiser)
- polyurethane (not containing CFCs)
- polysiloxanes
- polymethyl methacrylate
- polyvinyl alcohol
- polyvinyl butyral
- polyvinyl acetate

20 It is understood that such scraps are completely polymerized.

- Cured waste resins or condensation products including the following:
  - urea formaldehyde resins
  - phenol formaldehyde resins
  - melamine formaldehyde resins
  - epoxy resins
  - alkyd resins
  - polyamides
- The following fluorinated polymer wastes [21]
  - perfluoroethylene/propylene (FEP)
  - perfluoro alkoxyl alkane
  - tetrafluoroethylene/per fluoro vinyl ether (PFA)

- tetrafluoroethylene/per fluoro methylvinyl ether (MFA)

- polyvinylfluoride (PVF)

- polyvinylidenefluoride (PVDF)

B3020

Paper, paperboard and paper product wastes

The following materials, provided they are not mixed with hazardous wastes:

Waste and scrap of paper or paperboard of:

- unbleached paper or paperboard or of corrugated paper or paperboard

- other paper or paperboard, made mainly of bleached chemical pulp, not coloured in the mass

- paper or paperboard made mainly of mechanical pulp (for example, newspapers, journals and similar printed matter)

- other, including but not limited to 1) laminated paperboard 2) unsorted scrap

B3030

Textile wastes

The following materials, provided they are not mixed with other wastes and are prepared to a specification:

- Silk waste (including cocoons unsuitable for reeling, yarn waste and garnetted stock)
  - not carded or combed
  - other

21 Post-consumer wastes are excluded from this entry: - Wastes shall not be mixed - Problems arising from open-burning practices to be considered.

- Waste of wool or of fine or coarse animal hair, including yarn waste but excluding garnetted stock
  - noils of wool or of fine animal hair
  - other waste of wool or of fine animal hair
  - waste of coarse animal hair

- Cotton waste (including yarn waste and garnetted stock)
  - yarn waste (including thread waste)
  - garnetted stock
  - other
- Flax tow and waste
- Tow and waste (including yarn waste and garnetted stock) of true hemp (Cannabis sativa L.)
- Tow and waste (including yarn waste and garnetted stock) of jute and other textile bast fibres (excluding flax, true hemp and ramie)
- Tow and waste (including yarn waste and garnetted stock) of sisal and other textile fibres of the genus Agave
- Tow, noils and waste (including yarn waste and garnetted stock) of coconut
- Tow, noils and waste (including yarn waste and garnetted stock) of abaca (Manila hemp or Musa textilis Nee)
- Tow, noils and waste (including yarn waste and garnetted stock) of ramie and other vegetable textile

fibres, not elsewhere specified or included

- Waste (including noils, yarn waste and garnetted stock) of man-made fibres

  - of synthetic fibres

  - of artificial fibres

- Worn clothing and other worn textile articles

- Used rags, scrap twine, cordage, rope and cables and worn out articles of twine, cordage, rope or cables of textile materials

  - sorted

  - other

B3035

Waste textile floor coverings, carpets

B3040

Rubber wastes

The following materials, provided they are not mixed with other wastes:

- Waste and scrap of hard rubber (e.g., ebonite)

- Other rubber wastes (excluding such wastes specified elsewhere)

B3050

Untreated cork and wood waste:

- Wood waste and scrap, whether or not agglomerated in logs, briquettes, pellets or similar forms

- Cork waste: crushed, granulated or ground cork

B3060

Wastes arising from agro-food industries provided it is not infectious:

- Wine lees

- Dried and sterilized vegetable waste, residues and byproducts, whether or not in the form of pellets, of a kind used in animal feeding, not elsewhere specified or included

- Degras: residues resulting from the treatment of fatty substances or animal or vegetable waxes

- Waste of bones and horn-cores, unworked, defatted, simply prepared (but not cut to shape), treated with acid or degelatinised

- Fish waste

- Cocoa shells, husks, skins and other cocoa waste

- Other wastes from the agro-food industry excluding by-products which meet national and international requirements and standards for human or animal consumption

B3065

Waste edible fats and oils of animal or vegetable origin (e.g. frying oils), provided they do not exhibit an Annex III characteristic

B3070

The following wastes:

- Waste of human hair

- Waste straw

- Deactivated fungus mycelium from penicillin production to be used as animal feed

B3080

Waste parings and scrap of rubber

B3090

Paring and other wastes of leather or of composition leather not suitable for the manufacture of leather articles, excluding leather sludges, not containing hexavalent chromium compounds and biocides (note the related entry on list A A3100)

B3100

Leather dust, ash, sludges or flours not containing hexavalent chromium compounds or biocides (note the related entry on list A A3090)

B3110

Fellmongery wastes not containing hexavalent chromium compounds or biocides or infectious substances (note the related entry on list A A3110)

B3120

Wastes consisting of food dyes

B3130

Waste polymer ethers and waste non-hazardous monomer ethers incapable of forming peroxides

B3140

Waste pneumatic tyres, excluding those destined for Annex IVA operations

B4 Wastes which may contain either inorganic or organic constituents

B4010

Wastes consisting mainly of water-based/latex paints, inks and hardened varnishes not containing organic solvents, heavy metals or biocides to an extent to render them hazardous (note the related entry on list A A4070)

B4020

Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives, not listed on list A, free of solvents and other contaminants to an extent that they do not exhibit Annex III characteristics, e.g., water-based, or glues based on casein starch, dextrin, cellulose ethers, polyvinyl alcohols (note the related entry on list A A3050)

B4030

Used single-use cameras, with batteries not included on list A

Parties to the Basel Convention 2006

Only the information pertaining to the Convention as kept in the custody of the Secretary-General of the United Nations in his capacity as Depositary constitutes authentic information for the purposes of the Convention. Please consult the website of the Depositary for authoritative information (http://untreaty.un.org/), the following is issued for information purposes only.

Total number of Parties: 169

Entry into force: 5 May 1992, in accordance with article 25 (1) of the Convention.

Registration: 5 May 1992, No. 28911.

Participant	**Signature**	**Accession (a) Acceptance (A) Approval (AA) Formal confirmation (c) Ratification Succession(d)**
Afghanistan	22.03.89	
Albania		29.06.99 (a)
Algeria		15.09.98 (a)
Andorra		23.7.99 (a)
Antigua and Barbuda		05.04.93 (a)
Argentina	28.06.89	27.06.91
Armenia		01.10.99 (a)

Australia		05.02.92 (a)
Austria	19.03.90	12.01.93
Azerbaijan		01.06.01 (a)
Bahamas		12.08.92 (a)
Bahrain	22.03.89	15.10.92
Bangladesh		01.04.93 (a)
Barbados		24.08.95 (a)
Belarus		10.12.99 (a)
Belgium	22.03.89	01.11.93
Belize		23.05.97 (a)
Benin		04.12.97 (a)
Bhutan		26.08.02 (a)
Bolivia	22.03.89	15.11.96
Bosnia & Herzegovina		16.03.01 (a)
Botswana		20.05.98 (a)
Brazil		01.10.92 (a)
Brunei Darussalam		16.12.02 (a)
Bulgaria		16.02.96 (a)
Burkina Faso		04.11.99 (a)
Burundi		06.01.97 (a)
Cambodia		02.03.01 (a)
Cameroon		09.02.01 (a)
Canada	22.03.89	28.08.92
Cape Verde		02.07.99 (a)
Chad		10.03.04 (a)
Central African Republic		24.02.06 (a)
Chile	31.01.90	11.08.92
China [4]	22.03.90	17.12.91

Colombia	22.03.89	31.12.96
Comoros		31.10.94 (a)
Cook Islands		29.06.04 (a)
Costa Rica		07.03.95 (a)
Côte d'Ivoire		01.12.94 (a)
Croatia		09.05.94 (a)
Cuba		03.10.94 (a)
Cyprus	22.03.89	17.09.92
Czech Republic [5]		30.09.93 (d)
Democratic Republic of Congo		06.10.94 (a)
Denmark	22.03.89	06.02.94 (AA)
Djibouti		31.05.02 (a)
Dominica		05.05.98 (a)
Dominican Republic		10.07.00 (a)
Ecuador	22.03.89	23.02.93
Egypt [6]		08.01.93 (a)
El Salvador	22.03.90	13.12.91
Equatorial Guinea		07.02.03 (a)
Eritrea		10.03.05 (a)
Estonia		21.07.92 (a)
Ethiopia		12.04.00 (a)
European Community	22.03.89	07.02.94 (AA)
Finland	22.03.89	19.11.91 (A)
France	22.03.89	07.01.91 (AA)
Gambia		15.12.97 (a)
Georgia		20.05.99 (a)
Germany [7]	23.10.89	21.04.95

Ghana		30.05.03 (a)
Greece	22.03.89	04.08.94
Guatemala	22.03.89	15.05.95
Guinea		26.04.95 (a)
Guinea-Bissau		09.02.05 (a)
Guyana		04.04.01 (a)
Haiti	22.03.89	
Honduras		27.12.95 (a)
Hungary	22.03.89	21.05.90 (AA)
Iceland		28.06.95 (a)
India	15.03.90	24.06.92
Indonesia		20.09.93 (a)
Iran (Islamic Republic of)		05.01.93 (a)
Ireland	19.01.90	07.02.94
Israel	22.03.89	04.12.94
Italy	22.03.89	07.02.94
Jamaica		23.01.03 (a)
Japan		17.09.93 (a)
Jordan	22.03.89	22.06.89 (AA)
Kazakhstan		03.06.03 (a)
Kenya		01.06.00 (a)
Kiribati		07.09.00 (a)
Kuwait	22.03.89	11.10.93
Kyrgyzstan		13.08.96 (a)
Latvia		14.04.92 (a)
Lebanon	22.03.89	21.12.94
Lesotho		31.05.00 (a)
Liberia		22.09.04 (a)

Libyan Arab Jamahiriya		12.07.01 (a)
Liechtenstein	22.03.89	27.01.92
Lithuania		22.04.99 (a)
Luxembourg	22.03.89	07.02.94
Madagascar		02.06.99 (a)
Malawi		21.04.94 (a)
Malaysia		08.10.93 (a)
Maldives		28.04.92 (a)
Mali		05.12.00 (a)
Malta		19.06.00 (a)
Marshall Islands		27.01.03 (a)
Mauritania		16.08.96 (a)
Mauritius		24.11.92 (a)
Mexico	22.03.89	22.02.91
Micronesia (Federated States of)		06.09.95 (a)
Monaco		31.08.92 (a)
Mongolia		15.04.97 (a)
Montenegro [8]		22.11.06 (d)
Morocco		28.12.95 (a)
Mozambique		13.03.97 (a)
Namibia		15.05.95 (a)
Nauru		12.11.01 (a)
Nepal		15.10.96 (a)
Netherlands [9]	22.03.89	16.04.93 (A)
New Zealand [10]	18.03.89	20.12.94
Nicaragua		03.06.97 (a)
Niger		17.06.98 (a)
Nigeria	15.03.90	13.03.91

Norway	22.03.89	02.07.90
Oman		08.02.95 (a)
Pakistan		26.07.94 (a)
Panama	22.03.89	22.02.91
Papua New Guinea		01.09.95 (a)
Paraguay		28.09.95 (a)
Peru		23.11.93 (a)
Philippines	22.03.89	21.10.93
Poland	22.03.90	22.03.92
Portugal [11]	26.06.89	26.01.94
Qatar		09.08.95 (a)
Republic of Korea		28.02.94 (a)
Republic of Moldova		02.07.98 (a)
Romania		27.02.91 (a)
Russian Federation	22.03.90	31.01.95
Rwanda		07.01.04 (a)
Saint Kitts and Nevis		07.09.94 (a)
Saint Lucia		09.12.93 (a)
Saint Vincent and the Grenadines		02.12.96 (a)
Samoa		22.03.02 (a)
Saudi Arabia	22.03.89	07.03.90
Senegal		10.11.92 (a)
Serbia [14]		18.04.00 (a)
Seychelles		11.05.93 (a)
Singapore		02.01.96 (a)
Slovakia [5]		28.05.93 (d)
Slovenia		07.10.93 (a)
South Africa		05.05.94 (a)

Spain	22.03.89	07.02.94
Sri Lanka		28.08.92 (a)
Sudan		09.01.06 (a)
Swaziland		08.08.05 (a)
Sweden	22.03.89	02.08.91
Switzerland	22.03.89	31.01.90
Syrian Arab Republic	11.10.89	22.01.92
Thailand	22.03.90	24.11.97
The former Yugoslav Republic of Macedonia		16.07.97 (a)
Togo		02.07.04 (a)
Trinidad and Tobago		18.02.94 (a)
Tunisia		11.10.95 (a)
Turkey	22.03.89	22.06.94
Turkmenistan		25.09.96 (a)
Uganda		11.03.99 (a)
Ukraine		08.10.99 (a)
United Arab Emirates	22.03.89	17.11.92
United Kingdom of Great Britain and Northern Ireland [4, 12]	06.10.89	07.02.94
United Republic of Tanzania		07.04.93 (a)
United States of America [13]	22.03.90	
Uruguay		20.12.91
Uzbekistan		07.02.96 (a)
Venezuela	22.03.89	03.03.98
Viet Nam		13.03.95 (a)
Yemen		21.02.96 (a)
Zambia		15.11.94 (a)

Signatories of the Basel Convention which have not deposed instruments of ratifications: Afghanistan, Haiti, United States of America

Declarations

(Unless otherwise indicated, the declarations were made upon formal confirmation, ratification, acceptance, approval, accession or succession. For objections thereto, see hereinafter.)

Algeria

Declaration:

The Government of the People's Democratic Republic of Algeria declares, with regard to article 20, paragraph 2 of the [Convention], that in every case, the agreement of the all parties concerned is necessary to submit a dispute to the International Court of Justice or to arbitration.

Chile

Declaration:

The Government of Chile considers that the provisions of this Convention [. . .] help to consolidate and expand the legal regime that Chile has established through various international instruments on the control of transboundary movements of hazardous wastes and their disposal, whose scope of application covers both the continental territory of the Republic and its area of jurisdiction situated south of latitude 60^0S, in accordance with the provisions of article 4, paragraph 6, of the present Convention.

Colombia

Upon signature:

It is the understanding of Colombia that the implementation of the present Convention shall in no case restrict, but rather shall strengthen, the application of the juridical and political principles which, as [was] made clear in the statement [made on 21 March to the Basel Conference], govern the actions taken by the Colombian State in matters covered by the Convention -- in other words, *inter alia*, the latter may in no case be interpreted or applied in a manner inconsistent with the competence of the Colombian State to apply those principles and other norms of its internal rule to its land area (including the subsoil), air space, territorial sea, submarine continental shelf and exclusive economic maritime zone, in accordance with international law.

Upon ratification:

The Government of Colombia, pursuant to article 26, paragraph 2, of the [said Convention], declares, for the purposes of implementing this international instrument, that article 81 of the Political Constitution of Colombia prohibits the bringing of nuclear residues and toxic wastes into the national territory.

Cuba

Declaration:

The Government of the Republic of Cuba declares, with regard to article 20 of the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, that any disputes between Parties as to the interpreta- tion or application of, or compliance with, this Convention or any protocol thereto, shall be settled through negotiation through the diplomatic channel or submitted to arbitration under the conditions set out in Annex

VI on arbitration.

Denmark

Upon signature:

"Denmark's signature of the Global Convention of the Con- trol of Transboundary Movements of Hazardous Wastes and their Disposal does not apply to Greenland and the Faroe Islands."

Ecuador

Upon signature:

The elements contained in the Convention which has been signed may in no way be interpreted in a manner inconsistent with the domestic legal norms of the Ecuadorian State, or with the exercise of its national sovereignty.

Germany[7]

Declaration made upon signature and confirmed upon ratifica- tion:

"It is the understanding of the Government of the Federal Republic of Germany that the provisions in article 4, paragraph 12 of this Convention shall in no way affect the exercise of navigation rights and freedoms as provided for in international law. Accordingly, it is the view of the Government of the Federal Republic of Germany that nothing in this Convention shall be deemed to require the giving of notice to or the consent of any State for the passage of hazardous wastes on a vessel under the flag of a party exercising its right of innocent passage through the territorial sea or the freedom of navigation in an exclusive economic zone under international law."

Indonesia

Declaration:

Mindful of the need to adjust the existing national laws and regulations, the provisions of article 3 (1) of this Convention shall only be implemented by Indonesia after the new revised laws and regulations have been enacted and entered into force.

Italy

Declaration made on 30 March 1990 and confirmed upon ratification:

The Government of Italy declares . . . that it is in favour of the establishment of a global control system for the environmentally sound management of transboundary movements of hazardous wastes.

Japan

Declaration:

The Government of Japan declares that nothing in the Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal be interpreted as requiring notice to or consent of any State for the mere passage of hazardous wastes or other wastes on a vessel exercising navigational rights and freedoms, as paragraph 12 of article 4 of the said Convention stipulates that nothing in the Convention shall affect in any way the exercise of navigational rights and freedoms as provided for in international law and as reflected in relevant international instruments.

Lebanon

Upon signature:

"[Lebanon] declares that [it] can under no circumstances permit burial of toxic and other wastes in any of the areas subject to its legal authority which they have entered illegally. In 1988, Lebanon announced a total ban on the import of such wastes and adopted Act No. 64/88 of 12 August 1988 to that end. In all such situations, Lebanon will endeavour to co-operate with the States concerned, and with the other States parties, in accordance with the provisions of this treaty."

Mexico

Declaration made upon signature and confirmed upon ratification:

Mexico is signing *ad referendum* the Basel Convention on the Control of the Transboundary Movements of Hazardous Wastes and their disposal because it duly protects its rights as a coastal State in the areas subject to its national jurisdiction, including the territorial sea, the exclusive economic zone and the continental shelf and, in so far as it is relevant, its airspace, and the exercise in those areas of its legislative and administrative competence in relation to the protection and preservation of the environment, as recognized by international law and, in particular, the law of the sea. Mexico considers that, by means of this Convention, important progress has been made in protection of the environment through the legal regulation of transboundary movements of hazardous wastes. A framework of general obligations for States parties has been established, fundamentally with a view to reducing to a minimum the generation and transboundary movement of dangerous wastes and ensuring their environmentally rational management, promoting international co-operation for those purposes, establishing co-ordination and follow-up machinery and regulating the implementation of procedures for the peaceful settlement of disputes. Mexico further hopes that, as an essential supplement to the standard-setting character of the Convention, a protocol will be adopted as soon as possible, establishing, in accordance with the principles and provisions of international law, appropriate procedures in the matter of responsibility and compensation for damage resulting from the transboundary movement and management of dangerous wastes.

Norway

"Norway accepts the binding means of settling disputes set out in Article 20, paragraphs 3 (*a*) and (*b*), of the Convention, by (*a*) submission of the dispute to the International Court of Justice and/or (*b*) arbitration in accordance with the procedures set out in Annex VI."

Poland

Declaration:

With respect to article 20, paragraph 2, of the Convention, the Polish Republic declares that it recognizes submission to arbitration in accordance with the procedures and under the conditions set out in Annex VI to the Convention, as compulsory *ipso facto*.

Romania

Declaration:

In conformity with article 26, paragraph 2, of the Convention, Romania declares that the import and the disposal on its national territory of hazardous wastes and other wastes can take place only with the prior approval of the competent Romanian authorities.

Russian Federation

Understanding:

The definition of "Territory" in the Cairo Guidelines and Principles for the Environmentally Sound Management of Hazardous Wastes (UNEP Governing Council decision 14/30 of 17 June 1987) to which reference is made in the preamble to the Convention is a special formulation and cannot be used for purposes of interpreting the present Convention or any of its provisions in the light of article 31, paragraph 2, or article 32 of the 1969 Vienna Convention on the Law of

Treaties or on any other basis.

Saint Kitts and Nevis

Declaration:

"With respect to article 20, paragraph 2 of the Convention, the Government of Saint Kitts and Nevis declares that it recognizes submission to arbitration in accordance with the procedures and the conditions set out in Annex VI to the Convention, as compulsory *ipso facto* ."

Singapore

Declaration:

"The Government of Singapore declares that, in accordance with article 4 (12), the provisions of the Convention do not in any way affect the exercise of navigational rights and freedoms as provided in international law. Accordingly, nothing in this Convention requires notice to or consent of any State for the passage of a vessel under the flag of a party, exercising rights of passage through the territorial sea or freedom of navigation in an exclusive economic zone under international law."

Spain

Declaration:

The Spanish Government declares, in accordance with article 26.2 of the Convention, that the criminal characterization of illegal traffic in hazardous wastes or other wastes, established as an obligation of States Parties under article 4.3, will in future take place within the general framework of reform of the substantive criminal legal order.

United Kingdom of Great Britain and Northern Ireland

Declaration made upon signature and confirmed upon ratifica- tion:

"The Government of the United Kingdom of Great Britain and Northern Ireland declare that, in accordance with article 4 (12), the provisions of the Convention do not affect in any way the exercise of navigational rights and freedoms as provided for in international law. Accordingly, nothing in this Convention requires notice to or consent of any state for the passage of hazardous wastes on a vessel under the flag of a party, exercising rights of passage through the territorial sea or freedom of navigation in an exclusive economic zone under international law."

Uruguay

Upon signature:

Uruguay is signing *ad referendum* the Convention on the Control of the Transboundary Movements of Hazardous Wastes and their Disposal because it is duly protecting its rights as a riparian State in the areas subject to its national jurisdiction, including the territorial sea, the exclusive economic zone and the continental shelf and, as appropriate, the superjacent air space as well as the exercise in such areas of its standard-setting and administrative competence in connection with the protection and preservation of the environment as recognized by international law and, in particular, by the law of the sea.

Venezuela

Upon signature:

Venezuela considers that the Convention [as] adopted properly protects its sovereign rights as a riparian State over the areas under its national jurisdiction, including its territorial sea, exclusive economic zone and continental shelf, and, as appropriate, its air space. The Convention also safeguards the exercise in such areas of its standard-setting and administrative jurisdiction for the purpose of protecting and preserving the environment and its natural resources in

accordance with international law, and in particular the law of the sea.

Objections

(Unless otherwise indicated, the objections were received upon formal confirmation, ratification, acceptance, approval, accession or succession.)

Italy

The Government of Italy, in expressing its objections *vis-à-vis* the declarations made, upon signature, by the Governments of Colombia, Ecuador, Mexico, Uruguay and Venezuela, as well as other declarations of similar tenor that might be made in the future, considers that no provision of this Convention should be interpreted as restricting navigational rights recognized by international law. Consequently, a State party is not obliged to notify any other State or obtain authorization from it for simple passage through the territorial sea or the exercise of freedom of navigation in the exclusive economic zone by a vessel showing its flag and carrying a cargo of hazardous wastes.

Note: Information provided by the United Nations Office of Legal Affairs, New York. For more information on the status of the Convention, its amendments and related declarations as well as background information of key terms please check the website of the Treaty Section of the United Nations (which is now a pay site).

Notes

1. On 16 September 1992, i.e., after the expiry of the 90-day period from the date of its circulation (i.e., 10 June 1992), the Government of the United Kingdom of Great Britain and Northern Ireland communicated the following with respect to the corrections proposed by the Government of Japan to article 7 of the Convention:

"The United Kingdom Government has no objection to the first of the . . . suggested amendments since this represents the correction of a typographical error rather than a substantive change. With regard to the second proposed change, however, the UK Government would wish to lodge an objection on the following grounds:

i) Since the Convention was negotiated predominantly through the English language version of the draft Convention, to amend the text of this version to accord with the text of the other language versions would be to align the original version with translations, rather than vice-versa, which would appear to be more appropriate;

ii) There is a general presumption that a legislative provision should be construed, if at all possible, so as to give it meaning and substance. If the amendment proposed by the Japanese Government was to be accepted, article 7 would confirm what is already explicit in article 6.1 of the Convention (as read in conjunction with article 2.13 which defines the term `the states concerned'). If, however, article 7 remains un-amended, it will continue to add to the scope of article 6.2 and therefore retain a specific meaning;

iii) The United Kingdom is of the view that the Basel Convention should require of Parties the maximum level of prior notification possible. In the case of a proposed movement of a consignment of hazardous waste from the Basel Party to a second Basel Party via a non-Party, we would wish the second Basel Party to send a copy of its final response regarding movement to the non-Party. Article 7, as presently worded, ensures that this takes place. The amendment proposed by the Government of Japan would, however, have the effect of limiting, albeit to a small extent, the amount of prior notification by Parties to the agreement in question.

In view of these objections the government of the United Kingdom agrees to the first of the proposed adjustments of the English text, but not to the second."

On 11 January 1993, the Government of the United Kingdom notified the Secretary-General of its decision to withdraw the objection to the second modification proposed by the Government of Japan to article 7 of the Convention.

2. At the Fourth Meeting of the Conference of the Parties to the Convention, held in Kuching, Malaysia, from 23 to 27 February 1998, the Parties proposed an amendment to Annex I and adopted two new Annexes (VIII and IX).

In accordance with paragraphs 2 (c) and 3 of article 18, on the expiry of six months from the date of their circulation (on 6 May 1998), the amendment to Annex I and the adoption of Annexes VIII and IX became effective for all Parties to the Convention which had not submitted a notification in accordance with the provisions of article 18, paragraph 2 (b), that is to say on 6 November 1998.

In this connection, the Secretary-General had received from the Governments of the following States, notifications on the dates indicated hereinafter:

Austria (30 October 1998):

"Austria is not in a position to accept the amendment and the annexes to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention) which were adopted by decision IV/9 of the fourth meeting of the Conference of the Parties to the Basel Convention.

This objection under Article 18 para. 2 (b) of the said Convention has to be raised on purely technical grounds, due to the necessary parliamentary procedure in Austria, and will be lifted immediately once Parliament has accepted the amendment to Annex I as well as the new annexes VIII and IX.

In this context, due note should be taken of the fact that Austria is legally bound by the "Council Regulation on the supervision and control of shipments of waste within, into and out of the European Community". An amendment to Annex V of this Council Regulation has been decided with the support of Austria on 30 September 1998 in order to take into full consideration those wastes featuring on any lists of wastes characterized as hazardous for the purposes of the Basel Convention."

The amendment to Annex I and the adoption of Annexes VIII and IX took effect for Austria on 26 October 1999, the date of deposit of its instrument of acceptance with the Secretary-General.

Germany (4 November 1998):

At the Fourth Conference of the Parties to the Basel Convention held in Kuching, Malaysia from 23 to 27 February 1998, Germany agreed to the amendments and the new Annexes. However, under the Basic Law for the Federal Republic of Germany formal approval by the legislative bodies is required before the amendments to the Convention enter into force. Unfortunately, it will not be possible to conclude this process within the six-month deadline.

For this reason and in conformity with Article 18 (2) (b) of the Basel Convention, the Federal Republic of Germany declares that it cannot at present accept the amendments to Annex I and the new Annexes VIII and IX to the Basel Convention.

The amendment to Annex I and the adoption of Annexes VIII and IX took effect for Germany on 24 May 2002, the date of deposit of its instrument of acceptance with the Secretary-General.

3. Such an organization is defined under article 2, paragraph 20, of the said Convention as "an organization constituted by sovereign States to which its member States have transferred competence in respect of matters governed by this Convention and which has been duly authorized, in accordance with its internal procedures, to sign, ratify, accept, approve, formally confirm or accede to it"

4. On 6 and 10 June 1997, the Secretary-General received communications concerning the

status of Hong Kong from the Governments of the United Kingdom and China (see also note 2 under "China" and note 2 under "United Kingdom of Great Britain and Northern Ireland" regarding Hong Kong in the "Historical Information" section in the front matter of this volume). Upon resuming the exercise of sovereignty over Hong Kong, China notified the Secretary-General that the Convention will also apply to the Hong Kong Special Administrative Region.

5. Czechoslovakia had acceded to the Convention on 24 July 1991. See note 1 under "Czech Republic" and note 1 under "Slovakia" in the "Historical Information" section in the front matter of this volume

6. On 31 January 1995, the Government of Egypt informed the Secretary-General that its instrument of accession should have been accompanied by the following declarations:

First declaration: passage of ships carrying hazardous wastes through the Egyptian territorial sea:

The Arab Republic of Egypt, upon acceding to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which was done on 22 March 1989 and is referred to hereafter as "the Convention", and, in accordance with article 26 of the Convention, declares that:

In accordance with the provisions of the Convention and the rules of international law regarding the sovereign right of the State over its territorial sea and its obligation to protect and preserve the marine environment, since the passage of foreign ships carrying hazardous or other wastes entails many risks which constitute a fundamental threat to human health and the environment; and

In conformity with Egypt's position on the passage of ships carrying inherently dangerous or noxious substances through its territorial sea (United Nations Convention on the Law of the Sea, 1983), the Government of the Arab Republic of Egypt declares that

1. Foreign ships carrying hazardous or other wastes will be required to obtain prior permission from the Egyptian authorities for passage through its territorial sea.

2. Prior notification must be given of the movement of any hazardous wastes through areas under its national jurisdiction, in accordance with article 2, paragraph 9, of the Convention.

Second declaration: imposition of a complete ban on the import of hazardous wastes:

The Arab Republic of Egypt, upon acceding to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, which was signed on 22 March 1989 and is referred to below as "the Convention", and

In accordance with article 26 of the Convention, declares that:

In accordance with its sovereign rights and with article 4, paragraph 1(a), of the Convention, a complete ban is imposed on the import of all hazardous or other wastes and on their disposal on the territory of the Arab Republic of Egypt. This confirms Egypt's position that the transportation of such wastes constitutes a fundamental threat to the health of people, animals and plants and to the environment.

Third declaration:

The Governments of Bahrain, Belgium, Benin, Côte d'Ivoire, Denmark, Egypt, the Federal Republic of Germany, Finland, France, the German Democratic Republic, Ghana, Greece, Hungary, Italy, Jordan, Kenya, Kuwait, Lebanon, Luxembourg, Malaysia, Malta, Namibia, Netherlands, Niger, Norway, the Philippines, Portugal, Saudi Arabia, Senegal,Sweden, Switzerland, Turkey, the United Arab Emirates and the United Kingdom of Great Britain and Northern Ireland. Sweden, Switzerland, Turkey, the United Arab Emirates and the United Kingdom of Great Britain and Northern Ireland, as well as the Commission of the European Union, which will sign the Convention and/or the final document referring to the Control of Transboundary Movements of Hazardous Wastes and their Disposal (referred to hereinafter as

"the Convention"),

Concerned that the transboundary movement of hazardous wastes constitutes a great danger to the health of both humans and the environment,

Considering that the developing countries have a limited ability to manage wastes, especially hazardous wastes, in an environmentally sound manner,

Believing that a reduction in the production of hazardous wastes and their disposal in environmentally sound conditions in the country which exports them must be the goal of waste management policy,

Convinced that the gradual cessation of transboundary movements of hazardous wastes will undoubtedly be a major incentive to the development of appropriate national facilities for the disposal of wastes,

Recognizing the right of every State to ban the import to or export from its territory of hazardous wastes,

Welcoming the signature of the Convention,

Believing it necessary, before applying the provisions of the Convention, to impose immediate and effective control on transboundary movement operations, especially to developing countries, and to reduce them,

Declare the following:

1. The signatories to this Convention affirm their strong determination that wastes should be disposed of in the country of production.

2. The signatories to this Convention request States which accede to the Convention to do so, by making every possible effort to effect a gradual cessation of the import and export of wastes for reasons other than their disposal in facilities which will be set up within the framework of regional cooperation.

3. The signatories to this Convention will not permit wastes to be imported to or exported from countries deficient in the technical, administrative and legal expertise in administering wastes and disposing of them in an environmentally sound manner.

4. The signatories to this Convention affirm the importance of assistance to develop appropriate facilities intended for the final disposal of wastes produced by countries referred to in paragraph 3 above.

5. The signatories to this Convention stress the need to take effective measures within the framework of the Convention to enable wastes to be reduced to the lowest possible level and to be recycled.

Note:

Belgium considers that its declaration does not prejudice the import to its territory of wastes classified as primary or secondary materials.

These declarations were not transmitted to the Secretary-General at the time the instrument of accession. In keeping with the depositary practice followed in similar cases, the Secretary-General proposed to receive the declarations in question for deposit in the absence of any objection on the part of any of the Contracting States, either to the deposit itself or to the procedure envisaged, within a period of 90 days from the date of their circulation (i.e., 17 July 1995).

In this connexion, the Secretary-General received the following objections on the dates indicated hereinafter:

United Kingdom of Great Britain and Northern Ireland (9 October 1995):

"The Government of the United Kingdom of Great Britain and Northern Ireland cannot accept the first declaration of Egypt (passage of ships carrying hazardous wastes through the Egyptian territorial sea) [...]. Not only was this declaration out of time, but like all other declarations to similar effect, it is unacceptable in substance. In this connection the United Kingdom Government recalls its own statement upon signature confirmed upon ratification:

[For the text of the statement, see under "Reservations and Declarations".]

Finland (13 October 1995):

... "In the view of the Government of Finland the declarations of Egypt raise certain legal questions. Article 26.1 of the Basel Convention prohibits any reservation or exception to the Convention. However, according to article 26.2 a State can, when acceding to the Convention, make declarations or statements `with a view, inter alia, to the harmonization of its laws and regulations with the provisions of this Convention ...'.

Without taking any stand to the content of the declarations, which appear to be reservations in nature, the Government of Finland refers to article 26.2 of the Basel Convention and notes that the declarations of Egypt have been made too late. For this reason the Government of Finland objects to the declarations and considers them devoid of legal effect."

Italy (13 October 1995):

... The Italian Government objects to the deposit of the aforementioned declarations since, in its opinion, they should be considered as reservations to the Basel Convention and the possibility of making reservations is excluded under article 26, paragraph 1, of the Convention.

In any event, article 26, paragraph 2, stipulates that a State may, within certain limits, formulate declarations only "when signing, ratifying, accepting, approving, ... confirming or acceding to this Convention".

For these reasons, the deposit of the aforementioned declarations cannot be allowed, regardless of their content.

Netherlands (13 October 1995):

"While the second and the third declarations do not call for observations by the Kingdom, the first declaration establishing the requirement of prior permission for passage through the Egyptian territorial sea is not acceptable.

The Kingdom of the Netherlands considers the first declaration to be a reservation to the (Basel) Convention. The Convention explicitly prohibits the making of reservations in article 26 par. 1. Moreover, this reservation has been made two years after the accession of Egypt to the (Basel) Convention, and therefore too late.

Consequently the Kingdom of the Netherlands considers the declaration on the requirement of prior permission for passage through the territorial sea made by Egypt a reservation which is null and void."

Sweden (16 October 1995):

"The Government of Sweden cannot accept the declarations made by the Government of Egypt [...].

First, these declarations were made almost two years after the accession by Egypt contrary to the rule laid down in article 26, paragraph 2 of the Basel Convention.

Second, the content of the first of these declarations must be understood to constitute a reservation to the Convention, whereas the Basel Convention explicitly prohibits reservations

(article 26, paragraph 1).

Thus, the Government of Sweden considers these declarations null and void."

In view of the above and in keeping with the depositary practice followed in such cases, the Secretary-general has taken the view that he is not in a position to accept these declarations for deposit.

7. The German Democratic Republic had signed the Convention on 19 March 1989. See also note 2 under "Germany" in the "Historical Information" section in the front matter of this volume.

8. Information Note on Serbia and Montenegro:

The National Assembly of the Republic of Montenegro adopted its Declaration of Independence on 3 June 2006, following the referendum in the Republic of Montenegro on 21 May 2006, which took place pursuant to Article 60 of the Constitutional Charter of Serbia and Montenegro. The Republic of Serbia continued the membership of Serbia and Montenegro in the United Nations, including all organs and organizations of the United Nations system, on the basis of Article 60 of the Constitutional Charter of Serbia and Montenegro, activated by the Declaration of Independence adopted by the National Assembly of Montenegro on 3 June 2006. Accordingly, by a letter dated 3 June 2006, the President of the Republic of Serbia notified the Secretary-General that "membership of the state union of Serbia and Montenegro is continued by the Republic of Serbia in the United Nations, including all organs and organizations of the United Nations system".

Subsequently, in a letter dated 16 June 2006, the Minister for Foreign Affairs of the Republic of Serbia informed the Secretary-General that "the Republic of Serbia continues to exercise its rights and honour its commitments deriving from international treaties concluded by Serbia and Montenegro. Therefore, the Ministry of Foreign Affairs requests that the Republic of Serbia be considered a party to all international agreements in force, instead of Serbia and Montenegro. Furthermore, the Government of the Republic of Serbia will perform the functions formerly performed by the Council of ministers of the state union of Serbia and Montenegro as depositary for the corresponding multilateral treaties." Moreover, in a letter dated 30 June 2006, the Minister for Foreign Affairs of the Republic of Serbia confirmed that "all treaty actions undertaken by Serbia and Montenegro will continue in force with respect to the Republic of Serbia with effect from 3 June 2006. Therefore, all declarations, reservations and notifications made by Serbia and Montenegro will be maintained by the Republic of Serbia until the Secretary-General, as depositary, is duly notified otherwise."

9. For the Kingdom in Europe.

10. With a declaration of non-application to Tokelau "until the date of notification by the Government of New Zealand that the Convention shall so extend to Tokelau"

11. On 28 June 1999, the Government of Portugal informed the Secretary-General the the Convention would also apply to Macau.

Subsequently, on 9 and 15 December 1999, the Secretary-General received communications concerning the status of Macau from the Governments of the Portugal and China (see also note 3 under "China" and note 1 under "Portugal" regarding Macao in the "Historical Information" section in the front matter of this volume). Upon resuming the exercise of sovereignty over Macao, China notified the Secretary-General that the Convention with the will also apply to the Macao Special Administrative Region.

12. In respect of Great Britain and Northern Ireland and the British Antarctic Territory

Subsequently, on 30 October 1995, the Government of the the United Kingdom of Great Britain and Northern Ireland notified the Secretary-General that the Convention shall apply to Hong Kong (see also note 4), being a territory for whose international relations the Government of the United Kingdom is responsible.

On 6 July 2001, the Secretary-general received from the Government of Argentina, the following communication:

Following the notification by the Environment Agency of the United Kingdom of Great Britain and Northern Ireland of the possible transit of a cargo of hazardous wastes, the Government of Argentina rejected the British attempt to apply the above-mentioned Convention to the Malvinas Islands, South Georgia and South Sandwich Islands, as well as to the surrounding maritime spaces and to the Argentine Antarctic Sector.

The Argentine Republic reaffirms its sovereignty over the Malvinas Islands, South Georgia and South Sandwich Islands and the surrounding maritime spaces and rejects any British attempt to apply the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal of 22 March 1989 to the said Territories and maritime spaces.

It also wishes to recall that the General Assembly of the United Nations adopted resolutions 2065 (XX), 3160 (XXVIII), 31/49, 37/9, 38/12, 39/6, 40/21, 41/40, 42/19 and 43/25, which recognize the existence of a dispute over sovereignty and request the Governments of the Argentine Republic and the United Kingdom of Great Britain and Northern Ireland to initiate negotiations with a view to finding the means to resolve peacefully and definitively the pending problems between both countries, including all aspects on the future of the Malvinas Islands, in accordance with the Charter of the United Nations.

Further, on 12 December 2001, the Government of the United Kingdom of Great Britain and Northern Ireland informed the Secretary-General that "the Convention shall extend to the Isle of Man for whose international relations the Government of the United Kingdom is responsible" (on 27 November 2002: designation of authority: Department of Local Government and the Environment, Murray House, Mount Havelock, Douglas, Isle of Man, IM1 2SF).

On 27 November 2002: on behalf of the Bailiwick of Guernsey. (designation of authority: "Board of Health, David Hughes, Chief Executive, States of Guernsey Board of Health, John Henry House, Le Vauquiedor, St Martin's, Guernsey, GY4 6UU).

13 On 13 March 1996, the Secretary-General received from the Government of the United States of America, the following communication:

"(1) It is the understanding of the United States of America that, as the Convention does not apply to vessels and aircraft that are entitled to sovereign immunity under international law, in particular to any warship, naval auxiliary, and other vessels or aircraft owned or operated by a State and in use on government, non-commercial service, each State shall ensure that such vessels or aircraft act in a manner consistent with this Convention, so far as is practicable and reasonable, by adopting appropriate measures that do not impair the operations or operational capabilities of sovereign immune vessels.

(2) It is the understanding of the United States of America that a State is a `Transit State' within the meaning of the Convention only if wastes are moved, or are planned to be moved, through its inland waterways, inland waters, or land territory.

(3) It is the understanding of the United States of America that an exporting State may decide that it lacks the capacity to dispose of wastes in an `environmentally sound and efficient manner' if disposal in the importing country would be both environmentally sound and economically efficient.

(4) It is the understanding of the United States of America that article 9 (2) does not create obligations for the exporting State with regard to cleanup, beyond taking such wastes back or otherwise disposing of them in accordance with the Convention. Further obligations may be determined by the parties pursuant to article 12.

Further, at the time the United States of America deposits its instrument of ratification of the Basel Convention, the United States will formally object to the declaration of any State which asserts the right to require its prior permission or authorization for the passage of vessels transporting hazardous wastes while exercising, under international law, its right of innocent

passage through the territorial sea or freedom of navigation in an exclusive economic zone."

14 Information Note on Serbia and Montenegro:

The National Assembly of the Republic of Montenegro adopted its Declaration of Independence on 3 June 2006, following the referendum in the Republic of Montenegro on 21 May 2006, which took place pursuant to Article 60 of the Constitutional Charter of Serbia and Montenegro. The Republic of Serbia continued the membership of Serbia and Montenegro in the United Nations, including all organs and organizations of the United Nations system, on the basis of Article 60 of the Constitutional Charter of Serbia and Montenegro, activated by the Declaration of Independence adopted by the National Assembly of Montenegro on 3 June 2006. Accordingly, by a letter dated 3 June 2006, the President of the Republic of Serbia notified the Secretary-General that "membership of the state union of Serbia and Montenegro is continued by the Republic of Serbia in the United Nations, including all organs and organizations of the United Nations system".

Subsequently, in a letter dated 16 June 2006, the Minister for Foreign Affairs of the Republic of Serbia informed the Secretary-General that "the Republic of Serbia continues to exercise its rights and honour its commitments deriving from international treaties concluded by Serbia and Montenegro. Therefore, the Ministry of Foreign Affairs requests that the Republic of Serbia be considered a party to all international agreements in force, instead of Serbia and Montenegro. Furthermore, the Government of the Republic of Serbia will perform the functions formerly performed by the Council of ministers of the state union of Serbia and Montenegro as depositary for the corresponding multilateral treaties." Moreover, in a letter dated 30 June 2006, the Minister for Foreign Affairs of the Republic of Serbia confirmed that "all treaty actions undertaken by Serbia and Montenegro will continue in force with respect to the Republic of Serbia with effect from 3 June 2006. Therefore, all declarations, reservations and notifications made by Serbia and Montenegro will be maintained by the Republic of Serbia until the Secretary-General, as depositary, is duly notified otherwise."